ISSN 0002-9920

Notices

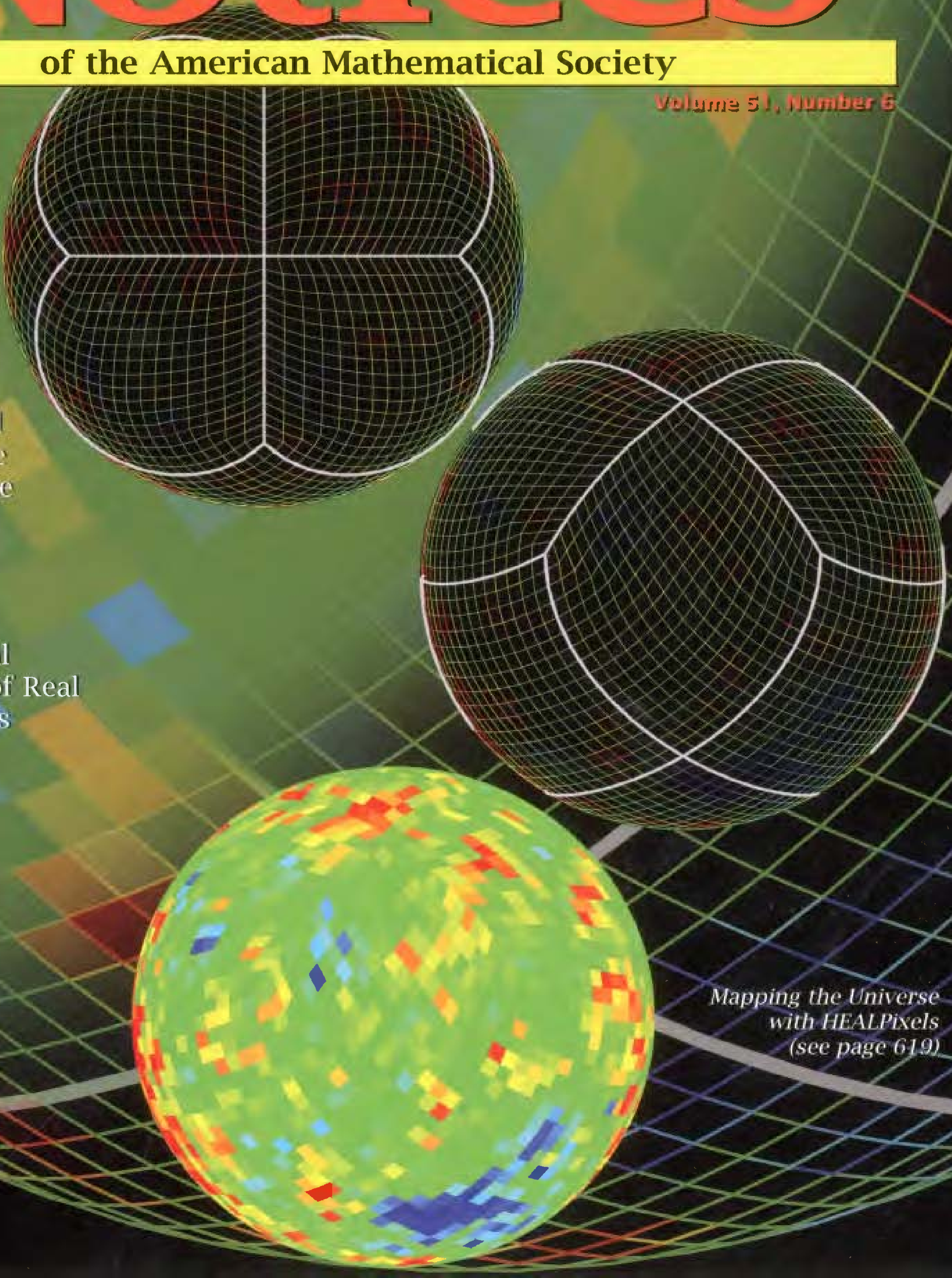
of the American Mathematical Society

June/July 2004

Volume 51, Number 6

The Poincaré Dodecahedral Space and the Mystery of the Missing Fluctuations
page 610

Combinatorial Equivalence of Real Moduli Spaces
page 620



Mapping the Universe with HEALPixels (see page 619)

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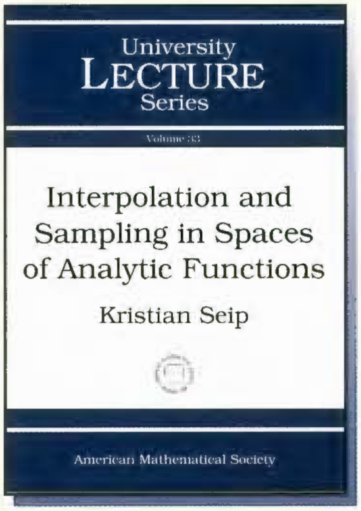
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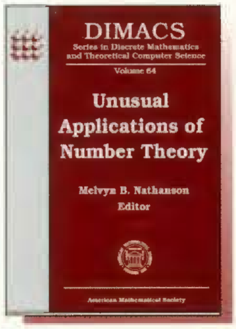
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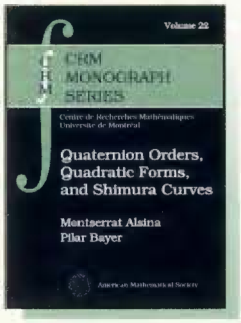
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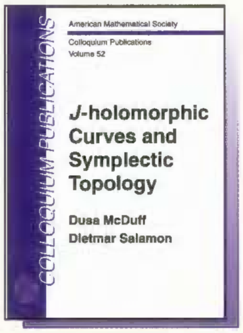
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Volume 52

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- Determining a Semisimple Group from Its Representation Degrees, *Michael Larsen*
- Global Fold Structure of the Miura Map on $L^2(\mathbb{T})$, *T. Kappeler and P. Topalov*
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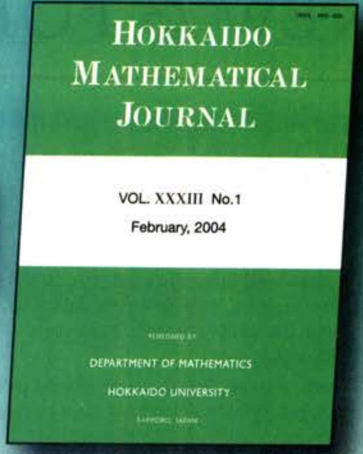
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MATHEMATICAL
JOURNAL

VOL. XXXIII No.1
February, 2004

PUBLISHED BY
DEPARTMENT OF MATHEMATICS
HOKKAIDO UNIVERSITY
SAPPORO, JAPAN

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June/July 2004

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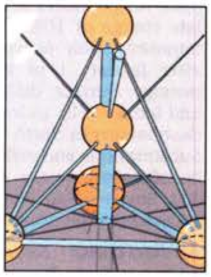
Jeffrey Weeks

The author presents a geometrical model of the spatial universe and the data from satellite mapping of background radiation used in the evaluation of such models.

620 Combinatorial Equivalence of Real Moduli Spaces

Satyan L. Devadoss

Real moduli spaces of Riemann surfaces are tiled by polyhedra, which permits their combinatorial visualization. The author explains this structure and its uses in proving equivalence.



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Mathematicians and Mathematics Educators Must Be Political!

All mathematical people, mathematicians, and mathematics educators must come together politically if the mathematics discipline is to survive. This reality has begun to permeate the visions of some in our community but must still come to the forefront for others.

The No Child Left Behind Act (NCLB, 2000) has as bases: every child must have access to a quality mathematics education, and every child has the right to be taught by a "highly qualified teacher." These bases are consistent with the Principles and Standards for School Mathematics (NCTM, 2000). However, implementation of the act has become highly problematic and points to a need for action.

To promote mathematics in this climate, NCTM (2003) adopted a political advocacy program that can be supported by all mathematical people in a proactive stance for the discipline. Planks include the following:

Equity. Every child has the right to be taught by a highly qualified teacher of mathematics, one who is knowledgeable in content, understands how students learn, and uses appropriate instructional methods. Every child must have the opportunity for the mathematics education required for an economically secure future, and no single test should limit future opportunities to learn mathematics.

Teacher Quality. All mathematical people must work to develop multiple effective routes to certification of highly qualified teachers. All routes must include strong mathematics content, knowledge of student learning, appropriate instructional methods, mentoring, and classroom experience.

We must ensure that teachers of mathematics (including postsecondary) commit to career-long professional growth and find support for the allocation of resources to achieve this goal. This means that (1) each beginning teacher needs a professional development plan for the future when they complete programs of study; (2) adequate federal funding continue for the National Science Foundation (NSF) for the support of innovative programs of professional development of mathematical people; and (3) proposals for NSF programs continue to be open to all to apply, to be peer reviewed, and to be of the highest intellectual content.

Research. All mathematical people must continue to improve the teaching and learning of mathematics, realizing that the complexity of schools and school systems requires the use of a variety of research methods—both quantitative and qualitative. We must teach the public that mathematical education research is not equivalent to medical research and cannot rely on commercial ventures for the research.

Significantly increased funding for research about student mathematics learning, curriculum materials, and effective classroom practices is necessary. No publisher, individual state, or school system can finance the scope and type of research needed to improve mathematics learning and teaching. Financing of the type used to produce the standards-based precollegiate curricula needs to be supported as innovations by NSF and the U.S. Department of Education.

Additionally, research on the impact of policies at all levels on school mathematics programs and on closing the achievement gap must be supported. Currently some NCLB policies may lead to increasing, not solving, problems in mathematics education.

Assessment. All mathematical people, teachers of mathematics, schools, students, families, and communities are together accountable for student achievement in mathematics. As responsible persons and institutions, we must work together to understand success and for whom, and when we are less successful, with whom. These ends require governmental resources for the development of new, accurate, and powerful tools to measure student learning of mathematics.

While supporting testing, we must guarantee that all testing be used only to improve student learning, not to limit access to future mathematics. Many adults come to mathematics late; we must do everything possible to keep access to mathematics open as long as possible for as many as possible. We should also remember that continual testing alone is no guarantee of learning.

Technology. All mathematical people must endorse the inclusion of and access to appropriate technologies, for all students, as part of a balanced mathematics curricular program. All should support teachers' use of innovative technologies that offer students better ways to learn mathematics for future study and the workplace. All must learn how mathematics at all levels has changed as a result of technology; all must consider what mathematics is now accessible that once was not and act accordingly.

We must support allocation of funds to provide all teachers of mathematics the time, training, and resources to incorporate technology into the learning environment.

Teacher Shortage and Retention. All mathematics people must work to attract and retain teachers of mathematics, elevate the status of the profession, and improve the working environment. We must attack incorrect public perceptions about mathematics and its teachers in the media and in the legislatures. It is time that we accept no bias against those who teach, study, and learn mathematics.

Can we as mathematical people afford not to promote mathematics with the platform outlined if our discipline is to survive?

—Johnny W. Lott, Immediate Past President
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Letters to the Editor

A Theorem of Bartle

In connection with the obituary of Robert G. Bartle (*Notices*, February 2004, page 239) I wish to draw attention to his beautiful paper "On compactness in functional analysis", *Trans. Amer. Math. Soc.* **79** (1955), 35–57. The paper is so nicely written that any beginning graduate student can follow it, and yet with the use of simple techniques, he derived several deep results as special cases.

—Som Naimpally
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(Received February 20, 2004)

Term Copyrights

In his discussion of copyright and scholarly journals (*Notices*, March 2004, page 309), John Ewing puts up some good arguments for the shortening of copyright terms. However, he sounds somewhat uncertain as to whether even his "Modest proposal" (28 years of protection, as it was in the first copyright law of 1709) can be realistically implemented any time soon.

I think the situation may be more promising if we do it in steps. As we are presently witnessing from the on-going fierce downloading battles between the record industry and the millions of music fans ("pirates"), social opposition to the present Draconian intellectual property laws is rising. Similar tensions are mounting around ludicrously broad patent laws, where excessive and frivolous patenting and numerous lawsuits often suppress technological innovation.

The scholarly community versus academic publishers is somewhat less visible in this debate, but many scientists view copyright as a nuisance. It brings almost no real benefit to them while seriously complicating (and often blocking) their access to archival literature. With relatively few exceptions of scientists publishing commercial books for the general public, the academic community has no real need for copyright. All we need is a reliable mechanism for establishing the authorship of scientific writings. Copyright is not essential for that.

Recognizing that copyright cannot be abolished overnight, my proposal is that publishing scientists should try to copyright their papers for a fixed, specifically indicated, short term, say for five or ten years. A copyright notice looking like "© 2004–2009" would mean that in 2010 the work enters the public domain. Even sporadic attempts of this kind may trigger an unstoppable trend.

—Alexander A. Berezin
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(Received March 14, 2004)

Teach More Math K–12

Anthony Ralston says much that is valuable and a few things that are doubtful ("Research mathematicians and mathematics education: A critique", April 2004, pages 403–11). I praise what is valuable in general and comment on what seems doubtful in particular.

Everybody knows what is wrong with K–12 education. To demonstrate this, carry out the following experiment. I have done this experiment many times with many different kinds of groups. Ask an audience to write down the one word that they imagine a K-12 student would use to describe their educational experience. Then ask the audience to say that word out loud. The word, even the pronunciation, comes as a chorus: Booooooorrrrrring!

The problem with K–12 education is that it teaches too little. The students are not challenged. They complain that they are treated like babies. They report that their teachers go over and over material that almost everyone in the class already knows and that the people who don't already know the material aren't listening. They say that busywork and daydreaming, not learning, make up the larger part of their school day. With this as a starting point, the system is unlikely to be improved by removing subjects from the curriculum.

Ralston supports the controversial position that we should remove long division from the curriculum. He points out, correctly, that there are other division algorithms that work just as well. This misses the point. The point is not which algorithm to teach but whether to teach any algorithm at all. What is the advantage in not knowing how to do long division? Students like to know how to do things. Taking long division out of the curriculum accomplishes nothing. Is long division a waste of time? I don't think so. But since we are already wasting most of their time for twelve years, I don't think the time saved by not teaching long division represents an appreciable saving.

More generally, Ralston expresses doubt about the usefulness of teaching any pencil-and-paper arithmetic. I use pencil-and-paper arithmetic all the time. I balance my checkbook while waiting in line at the bank. I play around with figures to get a feel for what minimum bid to list for an item on eBay. I do pencil-and-paper arithmetic on a plank before I begin to saw. What is the advantage in not knowing how to do pencil-and-paper arithmetic?

We need to teach more, not less. Teach mental arithmetic, pencil-and-paper arithmetic, calculator arithmetic, manipulatives, estimating, proofs, and word problems. The key word is "more". We need to teach more, not less. I am at a loss to understand people who recommend teaching less.

In my experience, students who cannot do pencil-and-paper arithmetic cannot do calculator arithmetic. I see more and more such students. Typically they are indifferent as to whether they push the plus button or the times button. It's all the same to them.

Each year fewer United States citizens get Ph.D.'s in math, science, and engineering than the year before. If we stop teaching pencil-and-paper arithmetic, we will not only have too few Ph.D's, we will have too few carpenters and plumbers.

Ralston's call for civility in the math wars I praise. When he slips into taking sides in the math wars, and he does (most clearly on pages 407–8), he loses me.

Teach more, not less.

—*Rick Norwood*
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(Received March 24, 2004)

Tutte and Beraha

We enjoyed reading the biographical sketch of William T. Tutte by Professor Hobbs and Professor Oxley in the March 2004 issue of the *Notices*. It was well written and comprehensive.

However, it seems to us that any discussion of chromials (chromatic polynomials) and their zeros ought to make mention of the Beraha numbers

$$B_n = 2 + 2\cos\left(\frac{2\pi}{n}\right)$$

and the Beraha conjecture, which states that for every n, B_n is the limit of zeros of an appropriately chosen family of chromials. Note that $B_5 = 1 + \tau \cong 2.618$, where τ is the *golden mean* equal to $\frac{1+\sqrt{5}}{2}$. Sami Beraha did prove his conjecture for B_5, B_7, and B_{10} by inventing appropriate families of planar graphs.

Professor Tutte not only mentioned Sami Beraha's conjecture several times in print but he was also the one who first named it "the Beraha conjecture" and called them "Beraha numbers". Professor Tutte and Sami had a long-standing relationship and were frequently in contact.

—*Robert Cowen and Joseph Kahane*
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(Received April 1, 2004)

Is Research in Mathematics Education Scientific?

Anthony Ralston berates in the April issue of the *Notices* the hubris and arrogance of research mathematicians who look down upon research in mathematical education. In view of the fact that the notion of the scientific is repeatedly used as a club to wield, it would not be amiss to remind ourselves of the basic criteria. Such criteria have been around for a long time, but they seem not to have been presented in explicit enough form. Three things characterize a scientific endeavor, namely:

1. A presence of a theory, which provides a general structure and in particular serves as a guide to what questions to ask and how to interpret answers and observations.

2. A methodology including tools with which problems can be addressed.

And finally, the sore point:

3. Confirmations to anchor the activity to reality.

This means in effect that a consensus can be made and in particular allows an outsider to judge. (The operation may have been successful, but the patient died.) More provocatively, recall Popper's dictum of science being an activity which is constantly trying to falsify itself.

So it would be a good exercise to think how mathematical education fares when viewed under (1), (2), and (3). I think especially (3) has been a problem for many mathematicians. Where are the results of mathematical education, results which we can ignore only at our peril?

Of course there are lots of worthwhile activities that do not satisfy these criteria, but most of these do not seek legitimacy through claiming scientific status. Thus in the absence of a true science of teaching and education, we have to resort to the notion of it being an art. And what is so terribly wrong with that? So my point here is not that teaching should be denigrated as being an elementary activity (although some educators have made grandiose pronouncements to the effect that the discipline eventually will clarify the nature of mathematical thinking per se) but that it is ill-served by claims of a spurious scientific legitimacy. In fact, in previous issues of the *Notices* some mathematical educators have warned against the "scientificism" of their discipline.

Thus I do not view mathematical education as a science but at its best as a discipline of philosophical reflection on the practice and goals of teaching, showing its mettle by providing exciting and surprising points of view not necessarily politically correct. And once again, is that not a worthy cause by itself?

My concern is political; namely, that it otherwise will claim for itself, by virtue not only of its very designation, the ultimate expertise on mathematical education, making itself unassailable to outside criticism.

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(Received April 7, 2004)

The *Notices* invites readers to submit letters and opinion pieces on topics related to mathematics. Electronic submissions are preferred (`notices-letters@ams.org`); see the masthead for postal mail addresses. Opinion pieces are usually one printed page in length (about 800 words). Letters are normally less than one page long, and shorter letters are preferred.

The Poincaré Dodecahedral Space and the Mystery of the Missing Fluctuations

Jeffrey Weeks

Introduction

Because of the finite speed of light, we see the Moon as it was roughly a second ago, the Sun as it was eight minutes ago, other nearby stars as they were a few decades ago, the center of our Milky Way Galaxy as it was 30,000 years ago, nearby galaxies as they were millions of years ago, and distant galaxies as they were billions of years ago. If we look still deeper into space, we see all the way back to the final stages of the big bang itself, when the whole universe was filled with a blazing hot plasma similar to the outer layers of the modern Sun. In principle we see this plasma in all directions; it fills the entire background of the sky. So why don't we notice it when we look up at the night sky? The catch is that the light from it—originally visible or infrared—over the course of its 13.7 billion-year voyage from the plasma to us has gotten stretched out as part of the overall expansion of the universe. Specifically, the universe has expanded by a factor of about 1100 from then till now, so what was once a warm reddish glow with a wavelength around 10,000 angstroms is now a bath of microwaves with a wavelength of about a millimeter. So we cannot see the plasma with our eyes, but we can see it with a microwave antenna.

If our eyes were sensitive to microwaves as well as to visible light, a close-up view of the night sky might look something like Figure 1. In the foreground we see other galaxies as they were a few billion years ago. In the background we see the omnipresent plasma as it was 380,000 years after the big bang, a mere three one-thousandths of one percent of the universe's present age of 13.7 billion years. The plasma holds clues to the universe's birth, evolution, geometry, and topology. To harvest these clues, NASA launched the Wilkinson Microwave Anisotropy Probe (WMAP) on 30 June 2001. On 10 August 2001 WMAP reached its orbit about the so-called second Lagrange point, where the combined gravity of the Sun and the Earth are just right to keep the satellite orbiting the Sun in synchronization with the Earth, and WMAP began its four years of observations (Figure 2). The observed radiation from the plasma, known as the Cosmic Microwave Background (CMB) radiation, is extremely uniform across the sky. Nevertheless, it exhibits small temperature fluctuations on the order of 1 part in 10^5. These CMB temperature fluctuations result from fluctuations in the density (not temperature!) of the primordial plasma: photons arriving from denser regions do a little extra work against gravity and arrive slightly cooler, while photons arriving from less dense regions do a little less work against gravity and arrive slightly warmer. So in effect temperature fluctuations on the microwave sky reveal density fluctuations in the early universe.

Cosmologists' current standard model posits an essentially infinite Euclidean space created by inflation and containing density fluctuations on all scales. On small scales WMAP observed these fluctuations as predicted. However, on scales larger than about 60° degrees across the sky, the

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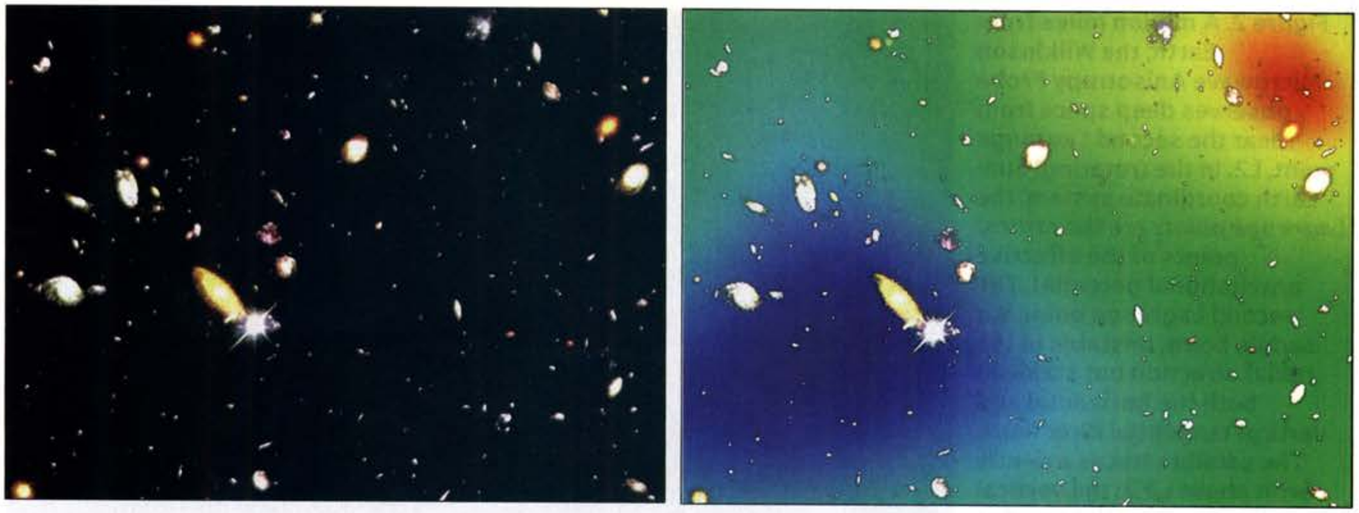
Jeffrey Weeks is a MacArthur Fellow. He can be reached at `http://www.geometrygames.org/contact.html`.



NASA/STScI.

Figure 1. The primordial plasma provides a background for the whole sky. However, we see it not in the visible spectrum but in microwaves. The left panel shows a portion of the Hubble Deep Field image as we see it with our eyes. The right panel simulates what we might see if our eyes were sensitive to microwaves as well as to visible light.

fluctuations all but disappear,[1] leaving cosmologists with the Mystery of the Missing Fluctuations.

Finite Universe

One possible explanation for the missing large-scale fluctuations is that the universe is simply not big enough to support them. To take a simple 1-dimensional analogy, an infinite line supports waves of all sizes, while the circumference of a unit circle supports no wavelength longer than 2π. Similarly, if the real universe is a closed 3-manifold, it can support no waves longer than its own "circumference".

What 3-manifolds shall we consider? Observational evidence implies the observable universe is homogeneous and isotropic to a precision of one part in 10^4, so consider manifolds that locally look like the 3-sphere S^3, Euclidean space E^3, or hyperbolic space H^3. To construct a finite universe, take the quotient X/Γ of the simply connected space $X = S^3, E^3$, or H^3 under the action of a discrete fixed point free group Γ of isometries.

Observational data suggest the observable universe either is flat or has a small curvature that is more likely positive than negative. More precisely, on a scale where $\Omega < 1$ indicates a hyperbolic universe, $\Omega = 1$ indicates a flat universe, and $\Omega > 1$ indicates a spherical universe, analysis of the WMAP data yields $\Omega = 1.02 \pm 0.02$ at the 1σ level [2]. The parameter Ω measures the average mass-energy density of space, which by general relativity completely determines the spatial curvature, with low density yielding a hyperbolic universe and high density yielding a spherical universe. By definition Ω is the ratio of the actual density to the critical density that a flat universe would require.

The huge sphere on which we observe the primordial plasma is called the *horizon sphere*, and its radius in the modern universe is our *horizon radius*. If we live in a finite universe X/Γ, then our *injectivity radius* is the radius of the smallest Earth-centered sphere that "reaches all the way around the universe" and intersects itself. Equivalently, the injectivity radius is the radius of the largest Earth-centered sphere whose interior is embedded. Twice the injectivity radius is thus the minimal circumference of the universe, starting from Earth. If our horizon radius exceeds our injectivity radius, then we can trace two different lines of sight to the same distant region of space, meaning that in principle we see multiple images of the same astronomical sources (galaxies, quasars, plasma,...) in different parts of the sky, making detection of the universe's topology vastly easier.

A flat manifold E^3/Γ allows no a priori relationship between the horizon radius and the injectivity radius, because the latter is essentially arbitrary. Given any proposed Euclidean group Γ, we may easily stretch or shrink its translational components, via a similarity, to obtain any prescribed injectivity radius. We therefore have no reason to expect the injectivity radius to be comparable to our horizon radius. Thus successfully detecting a flat topology E^3/Γ would require a huge amount of luck. In spite of the long a priori odds against it, the possibility of a finite flat universe E^3/Γ continues to receive a fair amount of attention, because WMAP's $\Omega = 1.02 \pm 0.02$ result

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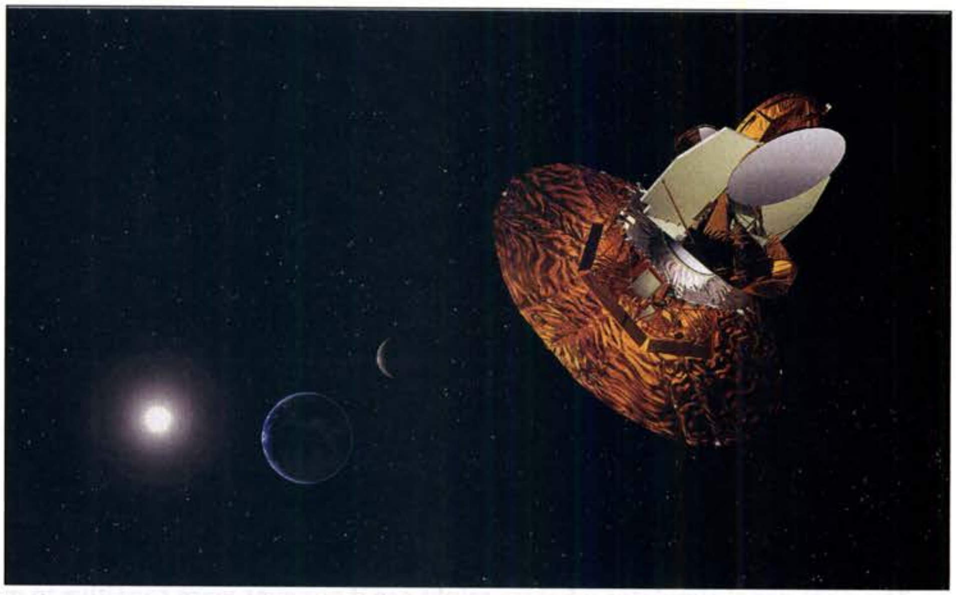
[1] *Spergel et al. report the missing fluctuations in one of a series of papers released along with the first-year WMAP data [1]. Their Figure 16 compares predictions to observations, showing, in their words, "the lack of any correlated signal on angular scales greater than 60 degrees." More conservative observers point out that the signal is not totally missing, but merely very weak. Spergel et al. estimate the probability that such a weak signal could arise by chance to be either 0.0015 or 0.003, depending on which of their best-fit flat space models one compares to.*

Figure 2. A million miles from Earth, the Wilkinson Microwave Anisotropy Probe observes deep space from near the second Lagrange point, L2. In the (rotating) Sun-Earth coordinate system, the *Lagrange points* are the critical points of the effective gravitational potential. The second Lagrange point is a saddle point, unstable in the radial direction but stable in both the horizontal and vertical tangential directions. The satellite traces a gentle orbit about L2 in the vertical plane, with a slight nudge every few months to keep it from drifting towards or away from the Sun. The backward-facing solar panels support a large protective disk blocking microwave interference from the Sun, Earth, and Moon, giving the outward-facing microwave receivers an unobstructed view of deep space.



Courtesy of NASA/WMAP Science Team.

comfortably includes it and because the Mystery of the Missing Fluctuations still begs for an explanation.

Even though the 1σ estimate $\Omega = 1.02 \pm 0.02$ leaves plenty of room for a hyperbolic universe, a finite hyperbolic topology H^3/Γ would be difficult to detect. As the complexity of a hyperbolic group Γ increases, the volume of its quotient H^3/Γ increases as well, in contrast to spherical groups Γ whose quotient spaces S^3/Γ get smaller as the group gets larger. Moreover, even in the smallest hyperbolic manifolds, the injectivity radius R_{inj} is typically larger than the horizon radius R_{hor}. Astrophysicists know our horizon radius to be about 46 billion light-years.[2] Geometers, however, want to know our horizon radius not in light-years but in units of the *curvature radius* R_{curv}. In other words, geometers want to know the dimensionless ratio R_{hor}/R_{curv}, which tells the horizon radius in radians or "the usual hyperbolic units". Even though the horizon radius R_{hor} in light-years is known, the curvature radius R_{curv} depends strongly on Ω. If $\Omega = 0.98$, then the curvature radius R_{curv} is about 98 billion light-years, the geometer's horizon radius works out to $R_{hor}/R_{curv} = 0.47$, and randomly placed observers in the ten smallest known hyperbolic topologies H^3/Γ would have roughly a 50-50 chance of living at a point where their horizon radius exceeds the injectivity radius. However, if $\Omega = 0.99$, then the curvature radius R_{curv} increases to about 139 billion light-years, the dimensionless horizon radius drops to $R_{hor}/R_{curv} = 0.33$, and a randomly placed observer has only about a 10 percent chance of living at a point where the horizon radius exceeds the injectivity radius. As Ω approaches 1, the curvature radius goes to infinity, and the chances of detecting the nontrivial topology go to zero.

More promising from a purely topological point of view is the possibility of a spherical universe S^3/Γ. The curvature radius R_{curv}, which here is simply the radius in meters of the 3-sphere S^3 from which the universe S^3/Γ is constructed, comes out to 98 billion light-years when Ω takes the observed value of 1.02. Thus the astrophysicist's horizon radius R_{hor} = 46 billion light-years translates to the geometer's horizon radius $R_{hor}/R_{curv} = 0.47$ radians. In other words, at the nominal value of $\Omega = 1.02$, our horizon sphere's radius on the 3-sphere is 0.47 radians, meaning that we are seeing a modest yet nontrivial portion of the 3-sphere (Figure 3). Luckily, a horizon radius of 0.47 suffices to see the topology S^3/Γ for many of the simplest and most natural groups Γ, to be discussed below. Moreover, for more complicated groups Γ, the quotient S^3/Γ gets smaller, making the topology even easier to detect. This potential detectability, along with WMAP's observation of $\Omega \approx 1.02$, has fuelled considerable interest in the possibility of a spherical universe S^3/Γ.

Whether we consider hyperbolic, flat, or spherical manifolds, the question remains: which spaces best account for the Mystery of the Missing

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[2] *Readers may wonder why the horizon has a 46 billion light-year radius when the universe is only 13.7 billion years old. The expanding universe provides the answer. The photons now reaching us from our horizon began their journey when the universe was 1100 times smaller than it is today. Thus the first light-year of space that a given photon traversed has since expanded to roughly 1100 light-years of space in the modern universe. In other words, the present day horizon radius is 46 billion light-years, but that same volume of space was much smaller, and more easily traversable, in the distant past.*

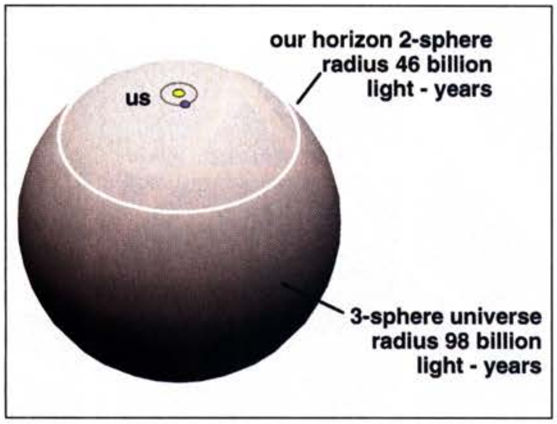

Figure courtesy of Bill Casselman.

Figure 3. At the nominal observed density $\Omega = 1.02$ the universe is positively curved with radius 98 billion light-years. Our horizon sphere has radius 46 billion light-years, which works out to 46/98 = 0.47 radians on the 3-sphere. Thus we see a modest but nontrivial portion of the 3-sphere.

Fluctuations? Surprisingly, not all small-volume universes suppress the large-scale fluctuations. As we will see below, some small-volume universes even elevate them!

Modes

A sustained musical tone may be expressed as the sum of a fundamental, a second harmonic, a third harmonic, and so on—in effect, its Fourier decomposition. This Fourier approach provides great insight into musical tones; for example, weak second and fourth harmonics characterize the sound of a clarinet. Similarly, any continuously defined field in the physical universe—for example, the density distribution of the primordial plasma—may be expressed as a sum of harmonics of 3-dimensional space. Technically these harmonics are the eigenmodes of the Laplace operator; intuitively they are the vibrational modes of the space, analogous to the vibrational modes of a 2-dimensional drumhead, so henceforth we will simply call them the *modes* of the space.

Just as the relative strengths of a clarinet's harmonics, its spectrum, characterize its sound, the relative strengths of the universe's modes characterize its physics. That is, just as the pressure and density fluctuations within the clarinet must conform to the clarinet's size and shape, the pressure and density fluctuations in the primordial plasma must conform to the size and shape of the universe. When we look out into space at our horizon, we see these density fluctuations. Of course we do not see the full 3-dimensional modes, but only their intersection with the 2-dimensional horizon sphere. Nevertheless, it is straightforward to calculate how a 3-manifold's modes restrict to 2-dimensional modes of the horizon sphere, ultimately allowing direct comparison to observations. Various sources of noise and other physical effects complicate the process but seem not to obscure the underlying topological and geometrical signatures. The strengths of the modes we observe on our 2-dimensional horizon sphere are called the *CMB power spectrum* (Figure 4). The CMB power spectrum's weak low-order terms conveniently quantify the Mystery of the Missing Large-Scale Fluctuations, just as the lack of low tones in a piccolo's spectrum reflect its small size.

The modes of a multiply connected space X/Γ, with $X = S^3$, E^3, or H^3 as before, lift in the obvious way to Γ-periodic modes of the simply connected space X. Conversely, each Γ-periodic mode of X

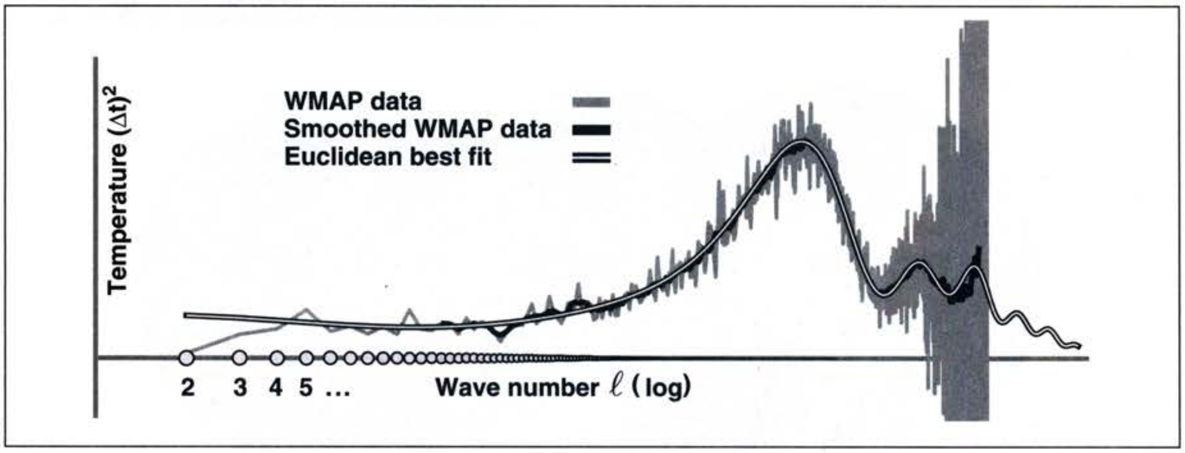

Figure courtesy of Bill Casselman.

Figure 4. Just as a musical tone splits into a sum of ordinary harmonics, the temperature fluctuations on our horizon sphere split into a sum of spherical harmonics. The resulting CMB power spectrum, shown here, tells much about the birth, evolution, geometry, and topology of the universe. The peaks in the spectrum fall more or less where expected, confirming physicists' theoretical understanding of the primordial plasma. The surprise lay in the weak lowest-order terms, which hint at a finite space.

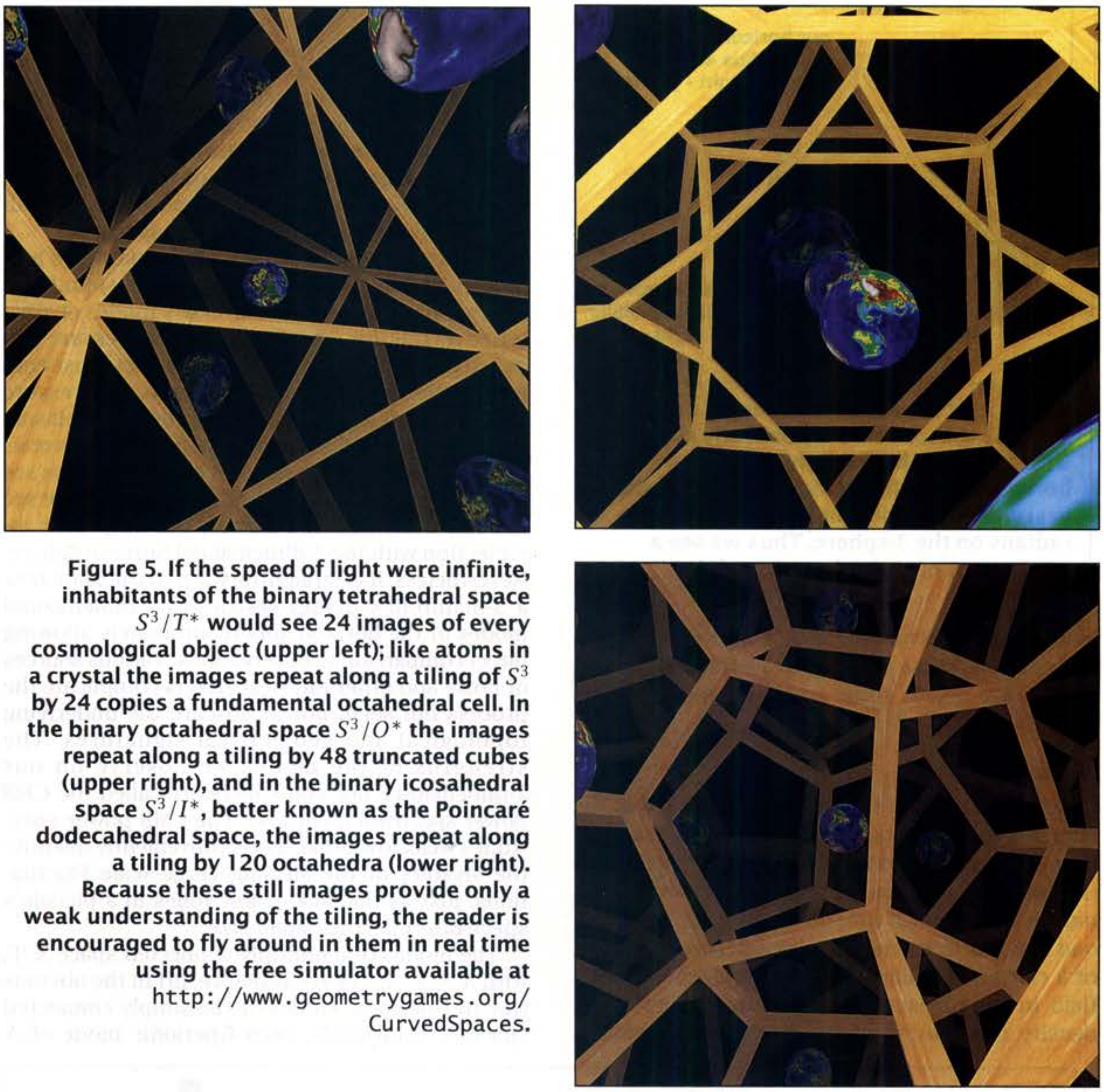

Figure 5. If the speed of light were infinite, inhabitants of the binary tetrahedral space S^3/T^* would see 24 images of every cosmological object (upper left); like atoms in a crystal the images repeat along a tiling of S^3 by 24 copies a fundamental octahedral cell. In the binary octahedral space S^3/O^* the images repeat along a tiling by 48 truncated cubes (upper right), and in the binary icosahedral space S^3/I^*, better known as the Poincaré dodecahedral space, the images repeat along a tiling by 120 octahedra (lower right). Because these still images provide only a weak understanding of the tiling, the reader is encouraged to fly around in them in real time using the free simulator available at `http://www.geometrygames.org/CurvedSpaces`**.**

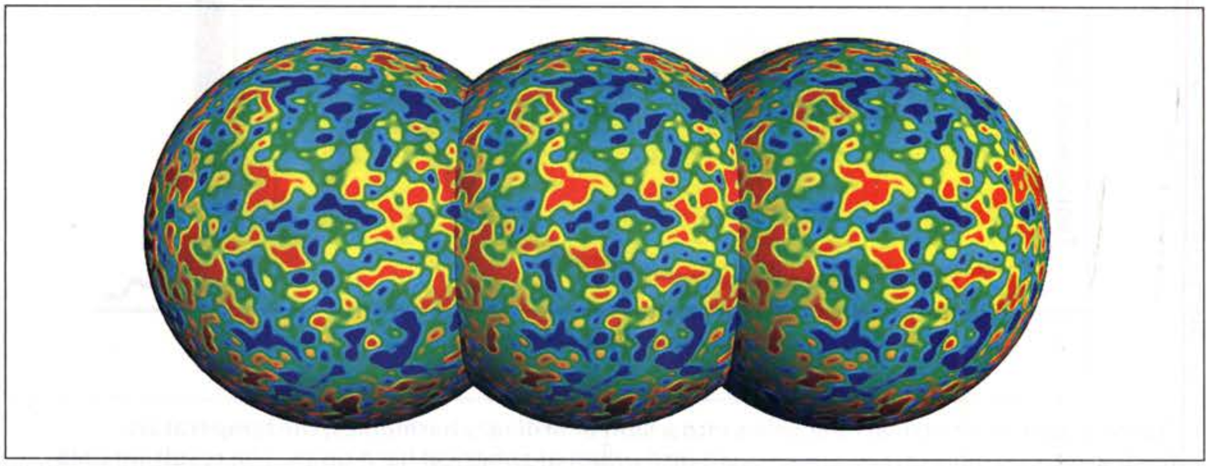

Figure 6. If our horizon radius exceeds our injectivity radius, the horizon sphere wraps all the way around the universe and intersects itself. Viewed in the universal cover, repeating images of the horizon sphere intersect. Observationally, we see the same circle of intersection on opposite sides of the sky.

projects down to a mode of the quotient X/Γ. Thus, even though we think of the modes conceptually as modes of X/Γ, in practice we invariably represent them as Γ-periodic modes of X.

In contrast to the irregular, hard-to-understand modes of hyperbolic space H^3, the modes of spherical space S^3 are regular and predictable. As a simple point of departure, consider the modes, or harmonics, of a circle S^1. Traditionally one writes them as $\{\{\cos\theta, \sin\theta\}, \{\cos 2\theta, \sin 2\theta\}, \dots\}$. Yet if we embed the circle as the set $x^2 + y^2 = 1$ in the xy-plane, we see that the transcendental functions $\cos\theta$ and $\sin\theta$ are completely equivalent to the linear functions x and y. Similarly, $\cos 2\theta$ and $\sin 2\theta$ become the quadratic polynomials $x^2 - y^2$ and $2xy$, and so on. In general, $\cos m\theta$ and $\sin m\theta$ become m^{th}-degree harmonic polynomials in x and y. By definition a polynomial $p(x_1, \dots, x_n)$ is *harmonic* if and only if it satisfies Laplace's equation $\nabla^2 p \equiv \frac{\partial^2 p}{\partial x_1^2} + \cdots + \frac{\partial^2 p}{\partial x_n^2} = 0$.

In perfect analogy to the modes of the circle S^1, the modes of the 2-sphere S^2 are precisely the homogeneous harmonic polynomials in x, y, and z, and the modes of the 3-sphere S^3 are precisely the homogeneous harmonic polynomials in x, y, z, and w. The only difference lies in the number of modes. On the circle the space of m^{th}-degree harmonic polynomials always has dimension 2, independent of m. On the 2-sphere the space of ℓ^{th}-degree harmonic polynomials has dimension $2\ell + 1$, and on the 3-sphere the space of k^{th}-degree harmonic polynomials has dimension $(k+1)^2$.

Cosmologists model the physics of a multiconnected spherical universe S^3/Γ using the Γ-periodic modes of S^3. For each degree k, the Γ-periodic modes form a subspace of the full $(k+1)^2$-dimensional mode space of S^3. Finding an orthonormal basis for that subspace requires, in principle, nothing more than a simple exercise in sophomore-level linear algebra. In practice the linear algebra works great for single-digit values of k but quickly bogs down as the size of the $(k+1)^2$-dimensional function space grows. Even simple cubic-time numerical matrix operations require $O(k^6)$ time on $(k+1)^2$-by-$(k+1)^2$ matrices, and efforts to work directly with the polynomials slow down even more dramatically. Adding insult to injury, accumulating round-off errors in floating point computations often render unusable the results of those computations that can be carried out within a reasonable time.

Thus for the past two years the main bottleneck for understanding and simulating the physics of multiconnected spaces X/Γ has been the efficient and accurate computation of the modes, the underlying local physics being already well understood. **News Flash:** Jesper Gundermann of the Danish Environmental Protection Agency has overcome the bottleneck and extended the CMB power spectra for various spherical spaces S^3/Γ from $\ell_{max} = 4$ out to $\ell_{max} = 15$. As this article goes to press, he is completing a rigorous statistical analysis, with results expected soon. His tentative results show an excellent fit.

Spherical Spaces

To recognize a spherical universe S^3/Γ by its imprint on the CMB power spectrum, we must first know which such spaces are possible. Fortunately 3-dimensional spherical spaces were classified by 1932 [3]. The possible groups Γ turn out to bear a close relationship to the symmetry groups of an ordinary 2-sphere! The easiest way to see the tight relationship between the symmetries of a 2-sphere and the symmetries of a 3-sphere is via the quaternions. Recall that the quaternions provide a noncommutative algebraic structure on $\mathbb{R}^4$ analogous to the commutative algebraic structure that the complex numbers provide on $\mathbb{R}^2$. Specifically the quaternions are spanned by $\{\mathbf{1}, \mathbf{i}, \mathbf{j}, \mathbf{k}\}$ subject to the rules $\mathbf{i}^2 = \mathbf{j}^2 = \mathbf{k}^2 = -\mathbf{1}$, $\mathbf{ij} = -\mathbf{ji} = \mathbf{k}$, $\mathbf{jk} = -\mathbf{kj} = \mathbf{i}$ and $\mathbf{ki} = -\mathbf{ik} = \mathbf{j}$. The length of a generic quaternion $a\mathbf{1} + b\mathbf{i} + c\mathbf{j} + d\mathbf{k}$ is just its obvious Euclidean length $\sqrt{a^2 + b^2 + c^2 + d^2}$. Just as the complex numbers restrict to a multiplicative group on the unit circle S^1, the quaternions restrict to a multiplicative group on the unit 3-sphere S^3.

Visualize the 3-sphere S^3 as the multiplicative group of unit length quaternions. A given quaternion $\mathbf{q} \in S^3$ can act on S^3 in two ways: by multiplication and by conjugation. When $\mathbf{q}$ acts by multiplication, taking each point $\mathbf{x} \in S^3$ to $\mathbf{qx}$, the result is a fixed-point free rotation of S^3. Any finite group Γ of such fixed-point free rotations defines a spherical space S^3/Γ.

When $\mathbf{q}$ acts by conjugation, taking each point $\mathbf{x} \in S^3$ to $\mathbf{qxq}^{-1}$, the result is a rotation with fixed points. Indeed, the point $\mathbf{1} \in S^3$ is fixed by all such rotations, because $\mathbf{q1q}^{-1} = \mathbf{1}$ for all $\mathbf{q}$, so in effect conjugation by $\mathbf{q}$ defines a rotation of the equatorial 2-sphere, which is the intersection of S^3 with the 3-dimensional subspace of purely imaginary quaternions $b\mathbf{i} + c\mathbf{j} + d\mathbf{k}$.

We now have a way to transfer symmetries from the 2-sphere to the 3-sphere. Start with a finite group of symmetries of S^2, for example, the tetrahedral group T consisting of the twelve orientation-preserving symmetries of a regular tetrahedron. Represent T as a set G of quaternions acting by conjugation. Now let the same set G act on S^3 by multiplication. Voilá! There is our group Γ of fixed-point free symmetries of the 3-sphere. The only catch is that each of the original symmetries of S^2 is realized by two different quaternions, $\mathbf{q}$ and $-\mathbf{q}$, so the group G has twice as many elements as the original group. In the present example, with the original group being the tetrahedral group T, the final group Γ is the *binary tetrahedral group* T^*, of order 24.

The finite symmetry groups of S^2 are well known:

- The *cyclic groups* Z_n of order n, generated by a rotation through an angle $2\pi/n$ about some axis.
- The *dihedral groups* D_m of order $2m$, generated by a rotation through an angle $2\pi/m$ about some axis as well as a half turn about some perpendicular axis.
- The *tetrahedral group* T of order 12 consisting of all orientation-preserving symmetries of a regular tetrahedron.
- The *octahedral group* O of order 24 consisting of all orientation-preserving symmetries of a regular octahedron.
- The *icosahedral group* I of order 60 consisting of all orientation-preserving symmetries of a regular icosahedron.

Transferring those groups from S^2 to S^3, as explained above, yields the single action symmetry groups of S^3:

- The cyclic groups Z_n of order n.
- The binary dihedral groups D^*_m of order $4m$, $m \geq 2$.
- The binary tetrahedral group T^* of order 24.
- The binary octahedral group O^* of order 48.
- The binary icosahedral group I^* of order 120.

The corresponding quotients S^3/Γ are the *single action spaces* (Figure 5). To fully understand these spaces, the reader is encouraged to fly around in them using the free simulator available at `www.geometrygames.org/CurvedSpaces`.

The full classification of finite fixed-point free symmetry groups of S^3 is more complicated, but only slightly. Geometrically, the mapping $\mathbf{x} \to \mathbf{qx}$ acts as a right-handed corkscrew motion. If we switch to right multiplication $\mathbf{x} \to \mathbf{xq}$, we get left-handed corkscrew motions instead of right-handed ones, and the quotient space S^3/Γ becomes the mirror image of what it had been. (To understand why changing $\mathbf{qx}$ to $\mathbf{xq}$ reverses the chirality of the corkscrew motion, multiply out the two products

$$(\cos\theta\mathbf{1} + \sin\theta\mathbf{i})(a\mathbf{1} + b\mathbf{i} + c\mathbf{j} + d\mathbf{k})$$

and

$$(a\mathbf{1} + b\mathbf{i} + c\mathbf{j} + d\mathbf{k})(\cos\theta\mathbf{1} + \sin\theta\mathbf{i})$$

and observe the results.) Two groups, Γ and Γ', may act on S^3 simultaneously, one by left multiplication and the other by right multiplication. The resulting quotient space is called a *double action space* (for details see [4]). So far cosmologists have largely neglected double action spaces and the related *linked action spaces*. One reason for the neglect is that they are more complicated and often require unrealistically large groups Γ. A more fundamental difficulty, however, is that a double action space is *globally inhomogeneous*, meaning its geometry and therefore the expected CMB power spectrum look different to observers sitting at different locations within the same space, while a single action space is *globally homogeneous*, meaning its geometry and the expected CMB fluctuations look the same to all observers. Obviously the single action spaces are far easier to simulate, because a single simulation suffices for all observers.

Encouraging News

Resolving the Mystery of the Missing Fluctuations turned out to be harder than expected. The principle that a small universe cannot support broad fluctuations was clear enough; the challenge lay in accounting for the particular CMB power spectrum that WMAP observed. In reality the $\ell = 2$ term, corresponding to a quadratic polynomial and generally called the *quadrupole*, was anomalously low (at the 1-in-100 level), while the $\ell = 3$ term, corresponding to a cubic polynomial and generally called the *octopole*, was somewhat low as well (at the 1-in-5 level). These 1-in-500 odds of weak low-ℓ fluctuations beg for an explanation, even though simple random chance cannot be excluded.

The reader may wonder what became of the lower-ℓ terms. The $\ell = 0$ constant term is simply the average CMB temperature. The $\ell = 1$ linear term, the *dipole*, is swamped by the far stronger dipole induced by the solar system's 300 km/sec motion relative to the CMB and is therefore unavailable.

Returning to the mysteriously low quadrupole and octopole, the simplest possible explanation, a flat 3-torus universe made by identifying opposite faces of a cubical block of space, failed to account for the observed power spectrum. A sufficiently small cubic 3-torus can of course suppress the quadrupole ($\ell = 2$) as strongly as desired, but not without suppressing other low-order modes ($\ell = 3, 4, 5$) along with it, contrary to observations. Making the 3-torus from a more general parallelepiped offers greater flexibility. The full 6-parameter space of parallelepipeds has yet to be fully explored, but initial investigations show that while noncubic rectangular 3-tori suppress the low-ℓ portion of the spectrum, they suppress the high-ℓ portion even more, leaving the low-ℓ portion *relatively* elevated [5], contrary to observation.

Among the spherical topologies, the lens spaces were considered first. A lens space $L(p,q)$ is the quotient S^3/Z_p of S^3 under the action of the cyclic group generated by

$$\begin{pmatrix} \cos\frac{2\pi}{p} & -\sin\frac{2\pi}{p} & 0 & 0 \\ \sin\frac{2\pi}{p} & \cos\frac{2\pi}{p} & 0 & 0 \\ 0 & 0 & \cos\frac{2\pi q}{p} & -\sin\frac{2\pi q}{p} \\ 0 & 0 & \sin\frac{2\pi q}{p} & \cos\frac{2\pi q}{p} \end{pmatrix}.$$

Because the group acts in only one direction, the quotient behaves roughly like a rectangular 3-torus that is narrow in one direction but wide in two others. Like a noncubic 3-torus, a lens space $L(p, q)$ suppresses the high-ℓ portion of the spectrum more heavily than the low-ℓ portion, in effect elevating the quadrupole and contradicting observations for all but the smallest choices of p.

The failures of both the rectangular 3-tori and the lens spaces to account for the low quadrupole combined to teach a useful lesson: a low quadrupole requires a *well-proportioned space*, with all dimensions of similar magnitude. Only in a well-proportioned space is the quadrupole suppressed more heavily than the rest of the power spectrum. This insight, combined with WMAP's hints of slight positive curvature, led researchers to consider the binary polyhedral spaces S^3/T^*, S^3/O^*, and S^3/I^*, all of which have both positive curvature and well-proportioned fundamental domains, namely a regular octahedron, a truncated cube, and a regular dodecahedron, respectively, as shown in Figure 5.

Of the binary polyhedral spaces, S^3/I^* seemed the most promising candidate, for the simple geometrical reason that its fundamental domain's inradius of $\pi/10 \approx 0.31$ fits easily within the horizon radius $R_{hor}/R_{curv} = 0.47$ corresponding to $\Omega = 1.02$. Topologists know S^3/I^* as the *Poincaré dodecahedral space.* Curiously, Poincaré himself never knew his namesake manifold could be constructed from a dodecahedron. Rather, he discovered the manifold in a purely topological context as the first example of a multiply connected homology sphere. A quarter century later Weber and Seifert glued opposite faces of a dodecahedron and proved that the resulting manifold was homeomorphic to Poincaré's homology sphere.

Lacking explicit formulas for the modes of the binary polyhedral spaces, the author and his colleagues computed the modes numerically. Unfortunately, in the case of the Poincaré dodecahedral space S^3/I^*, accumulating numerical errors limited the computation to the modes $k \le 24$ of the 3-dimensional space, in turn limiting the reliable portion of the predicted CMB power spectrum to $\ell = 2, 3, 4$. Nevertheless, the results were delightful: the predicted quadrupole ($\ell = 2$) and octopole ($\ell = 3$) matched observations [6]! (The $\ell = 4$ term was used to set the overall normalization.) Moreover, the best fit occurred in the range $1.01 < \Omega < 1.02$, comfortably within WMAP's observation of $\Omega = 1.02 \pm 0.02$.

Several factors made this result especially elegant. First and foremost was the near total lack of free parameters. Unlike the 3-torus, which can be made from an arbitrary parallelepiped (six degrees of freedom), the dodecahedral space can be made only from a perfectly regular dodecahedron (zero degrees of freedom). Second, the dodecahedral space is globally homogeneous. Unlike in a typical 3-manifold where the observer's position affects the expected CMB power spectrum (three degrees of freedom), the dodecahedral space looks the same to all observers (zero degrees of freedom). The only free parameter in our simple initial study was the density parameter Ω. Amazingly, with only one parameter to vary, the model correctly accounted for three independent observations: the quadrupole ($\ell = 2$), the octopole ($\ell = 3$), and the observed density itself. While far from a proof, such results were most encouraging.

Discouraging News

The dodecahedral model makes three testable predictions:

1. the weak large-scale CMB fluctuations,
2. matching circles in the sky (to be discussed momentarily), and
3. a slight curvature of space.

The WMAP satellite had already observed the weak large-scale CMB fluctuations, so there is no problem with the first prediction.

As for the third prediction, current measurements ($\Omega = 1.02 \pm 0.02$) fail to distinguish flat space ($\Omega = 1$) from the slight curvature that the dodecahedral model requires ($\Omega \approx 1.02$). Fortunately, upcoming data may suffice, either within a year or two by combining the WMAP results with other data sets to narrow the error bars on Ω, or by the end of the decade if we wait for more precise CMB measurements from the European Space Agency's Planck satellite.

This leaves the second prediction, currently the most controversial one. The basic insight is as follows. If the fundamental dodecahedron is smaller than our horizon sphere, then the horizon sphere will "wrap around the universe" and intersect itself. This is most conveniently visualized in the universal covering space (Figure 6) where repeating images of the horizon sphere intersect their neighbors. From our vantage point on Earth, at the center of our horizon sphere we can see the same circle of intersection sitting on opposite sides of the sky. If the observed CMB temperature fluctuations depended only on plasma density fluctuations, then the two images, one in front of us and one behind us, would display identical temperature patterns. Locating such pairs of matching circles would conclusively prove the universe is finite and reveal its topology.

When the news appeared last October that the dodecahedral model accounts for the Mystery of the Missing Fluctuations, another group of researchers was simultaneously searching for matching circles. Their massive computer search was expected to take months on a cluster of PCs, but by October their program, while not yet finished with the whole search, had finished checking for the diametrically opposite circle pairs predicted by the dodecahedral model and had found none [7].

The failure to find matching circles disappointed everyone, but might not have dealt a fatal blow to the idea of a finite universe. The observed CMB temperature fluctuations depend not only on plasma density fluctuations but also on other factors such as the Doppler effect of the plasma's motion and the gravitational influences the CMB photons experience over the course of their 13.7 billion-year journey from the plasma to us. For the most part the circle searchers carefully accounted for these various sources of contamination. However, they neglected residual contamination from foreground sources within our own Milky Way Galaxy. Total foreground contamination is intense, and the WMAP team devoted considerable effort to subtracting as much of it as possible before releasing their cleaned CMB sky maps. Nevertheless, the remaining contamination is easily visible to the naked eye along the galactic equator and is likely strong enough to disrupt circle matching along a wider swath. Future work should reveal the extent to which the residual foreground contamination may or may not obscure matching circles after resolving questions about how to model it correctly.

If the technical details get resolved and the matching circles really are not there, would we conclude that the universe is infinite? Not at all! First there is the possibility that the universe is finite but much larger than our horizon, in which case we could not detect its topology. More practically, there is the possibility that the universe is comparable to, or slightly larger than, the horizon. Such a universe would not generate detectable circles but might still account for the Mystery of the Missing Fluctuations. All participants in recent discussions—circle searchers as well as dodecahedral space modelers—agree this is the obvious Plan B. But how can one hope to detect topology lying beyond our horizon? It may not be as hard as it seems. Just as one may deduce the full length of a guitar string merely by observing vibrations on its middle 80 percent (with the endpoints hidden from view!), one may in principle deduce the topology of the universe by observing density fluctuations within a limited volume.

Conclusion

Where will the conflicting pieces of evidence lead? To a "small" dodecahedral universe lying wholly within our horizon? To a somewhat larger universe lying just beyond our view but within our experimental grasp? Or to a presumed but unconfirmed infinite flat space? Over the course of the decade improved measurements of curvature should provide the decisive clue. If Ω is sufficiently close to 1, then the dodecahedral model is dead. However, if Ω is found to be near 1.02—and bounded away from 1—then the dodecahedral model or some variation of it will almost surely prove correct, whether or not matching circles are found. For now, the Missing Fluctuations remain a Mystery.

Added in Proof

Studies of the first-year WMAP data find that certain features of the low-order CMB harmonics align with the ecliptic plane at roughly the 99.9% confidence level. Such alignments call into question the presumed cosmic origins of the low-order harmonics, suggesting instead either some hitherto unknown solar system contribution to the CMB, or perhaps some error in the collection and processing of the data. The second-year WMAP data, originally expected by February 2004 but delayed due to unexpected surprises in the results, may soon shed additional light on these anomalies. If the true cosmological low-order harmonics, after subtracting off any solar system effects and/or processing errors, turn out to be even weaker than previously believed, then the Mystery of the Missing Fluctuations will deepen. However, the case for the dodecahedral topology would vanish, forcing researchers to reconsider other topologies—and perhaps other explanations—in light of the revised data.

Acknowledgment

I thank the MacArthur Foundation for its support.

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About the Cover

Mapping the Universe with HEALPixels

In Jeff Weeks's article, the data that go into his analysis of the cosmic microwave background radiation have been collected by the WMAP satellite, which scans different directions in the sky and records temperatures. Data are sampled and amalgamated according to a scheme called **HEALPix** (**H**ierarchical **E**qual **A**rea iso-**L**atitude **Pix**elization), which has become the standard tool for such measurements—for the WMAP satellite as well as for its successor, Planck, scheduled to be launched in 2007. According to **HEALPix** the sphere is first divided into twelve large zones (outlined in gray on the cover), and each of these in turn is parceled into N^2 smaller "pixels" where $N = 2^n$. For WMAP $N = 512$, which means $3,145,728$ pixels altogether, and Planck will have many more, so there is a lot of calculation to be done in dealing with these data.

There is no canonical way to partition a sphere into uniform small regions, since there are only five regular solids. Any scheme used must therefore choose among various tradeoffs. The principal characteristic feature of **HEALPix** is that its pixels are all of equal area, more or less in the shape of rhombi, as the cover shows. Different formulas are used to generate the shapes in the polar and equatorial regions, but both depend on Archimedes' Theorem that cylindrical projection is area preserving.

Several considerations in addition to efficiency go into devising such a scheme: regions of equal area minimize the effect of noise, among other things. The distribution of regions along parallels of latitude allows using the fast Fourier transform in decomposing the data into spherical harmonics. **HEALPix** is probably close to being as fast as possible in facilitating spherical harmonic analysis of astrophysical data. Faster known mathematical techniques are not practical in this context, requiring as they do a partition of the sphere that does not deal well with noise.

The **HEALPix** suite of programs, written in FORTRAN, is publicly available from `http://www.eso.org/science/healpix/`. This package includes a number of useful peripheral tools as well as core routines. The documentation explaining how to use it is good, although to a mathematician interested in understanding internals it will likely seem that the algorithms it incorporates are not well explained nor the programs themselves easy to follow.

The data for the cover are obtained by degradation from those in the file of internal linear combination data available at `http://lambda.gsfc.nasa.gov/product/map/m_products.cfm`.

I wish to thank William O'Mullane for making available to me his Java versions of portions of the **HEALPix** code, and Krzysztof Górski, the originator of **HEALPix**, for his spirited explanation of its role.

—Bill Casselman
Graphics Editor
(`notices-covers@ams.org`)

Combinatorial Equivalence of Real Moduli Spaces

Satyan L. Devadoss

Introduction

The Riemann moduli space $\mathcal{M}_g^n$ of surfaces of genus g with n marked points has become a central object in mathematical physics. Its importance was emphasized by Grothendieck in his famous *Esquisse d'un programme.* The special case $\mathcal{M}_0^n$ is a building block leading to higher genera, playing a crucial role in the theory of Gromov-Witten invariants, symplectic geometry, and quantum cohomology. There is a Deligne-Knudsen-Mumford compactification $\overline{\mathcal{M}}_0^n$ of this space coming from geometric invariant theory which allows collisions of points of the configuration space. This description comes from the repulsive potential observed by quantum physics: pushing particles together creates a spherical bubble onto which the particles escape [11]. In other words, as points try to collide, the result is a new bubble fused to the old at the point of collision where the collided points are now on the new bubble. The phenomena is dubbed as *bubbling*; the resulting structure is called a *bubble-tree.*

Our work is motivated by the *real* points $\overline{\mathcal{M}}_0^n(\mathbb{R})$ of this space, the set of points fixed under complex conjugation. These real moduli spaces have importance in their own right, beginning to appear in many areas. For instance, Goncharov and Manin [7] recently introduced $\overline{\mathcal{M}}_0^n(\mathbb{R})$ in discussing ζ-motives and the geometry of $\overline{\mathcal{M}}_0^n$.

The real spaces, unlike their complex counterparts, have a tiling that is inherently present in them. This allows one to understand and visualize them using tools ranging from arrangements to reflection groups to combinatorics. This article began in order to understand why the two pictures in Figure 12 are the same: both of them have identical cellulation, tiled by 60 polyhedra known as associahedra. It was Kapranov who first noticed this relationship, relating $\overline{\mathcal{M}}_0^n(\mathbb{R})$ to the braid arrangement of hyperplanes. We provide an intuitive, combinatorial formulation of $\overline{\mathcal{M}}_0^n(\mathbb{R})$ in order to show the equivalence in the figure. Along the way we provide a construction of the associahedron from truncations of certain products of simplices.

A configuration space of n ordered, distinct particles on a manifold M is defined as

$$C_n(M) = M^n - \Delta,$$
$$\text{where } \Delta = \{(x_1, \ldots, x_n) \in M^n \mid \exists\, i, j,\ x_i = x_j\}.$$

The recent work in physics around conformal field theories has led to an increased interest in the configuration space of n labeled points on the projective line. The focus is on a quotient of this space by $\mathbb{P}\mathrm{Gl}_2(\mathbb{C})$, the affine automorphisms on $\mathbb{CP}^1$. The resulting variety $\mathcal{M}_0^n$ is the moduli space of Riemann spheres with n labeled punctures.

Definition 1. *The* real *moduli space of n-punctured Riemann spheres is*

$$\mathcal{M}_0^n(\mathbb{R}) \;=\; C_n(\mathbb{RP}^1)/\mathbb{P}\mathrm{Gl}_2(\mathbb{R}),$$

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He was partially supported by NSF grant DMS-0310354.

where $\mathbb{P}\mathrm{Gl}_2(\mathbb{R})$ *sends three of the points to* $0, 1, \infty$.

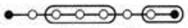
This moduli space encapsulates the new constructions of the associahedra developed below.

The Simplex

For a given manifold M, the symmetric group $\mathbb{S}_n$ acts freely on the configuration space $C_n(M)$ by permuting the coordinates, and the quotient manifold $B_n(M) = C_n(M)/\mathbb{S}_n$ is the space of n unordered, distinct particles on M. The closure of this space in the product is denoted by $B_n\langle M\rangle$. Let $\mathrm{Aff}(\mathbb{R})$ be the group of affine transformations of $\mathbb{R}$ generated by translating and scaling. The space $B_{n+2}(\mathbb{R})/\mathrm{Aff}(\mathbb{R})$ is the open n-simplex: the leftmost of the $n+2$ particles in $\mathbb{R}$ is translated to 0, and the rightmost is dilated to 1, and we have the subset of $\mathbb{R}^n$ where

$$0 < x_1 < x_2 < \cdots < x_{n-1} < x_n < 1. \tag{1}$$

The closure of this space is the n-simplex Δ_n whose codimension k face can be identified by the set of points with exactly k equalities of (1).

***Notation*.** *If we let* I_2 *denote the unit interval* $[0, 1] \subset \mathbb{R}$ *with* fixed *particles at the two endpoints, then the* n*-simplex can be viewed as the closure* $B_n\langle I_2\rangle$. *We use bracket notation to display this visually: Denote the* n *particles on the interval* I_2 *as nodes on a path, with the fixed ones as nodes shaded black. When the inequalities of (1) become equalities, draw brackets around the nodes representing the set of equal points on the interval. For example,*  *corresponds to the configuration*

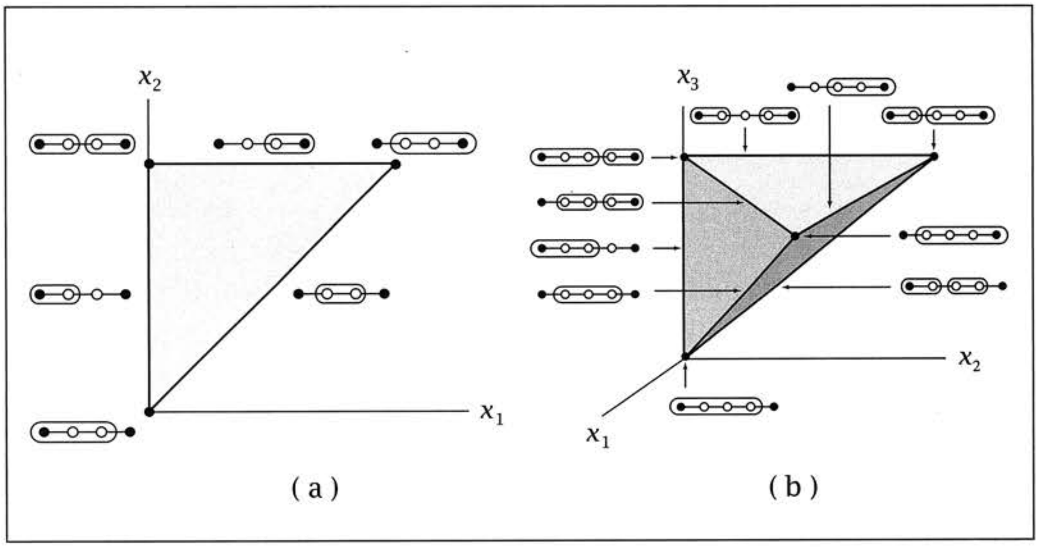


Figure 1. Labeling of vertices and edges of Δ_2 and Δ_3.

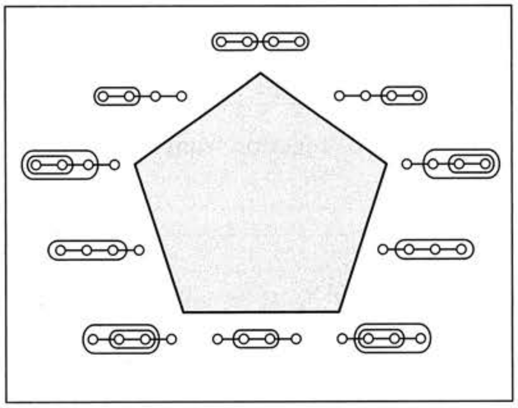


Figure 2. Associahedron K_4.

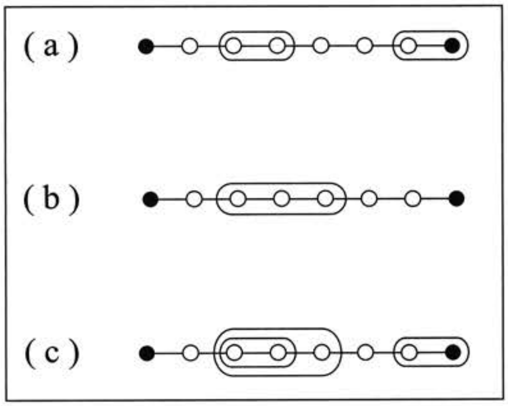


Figure 3. Compatibility of bracketings.

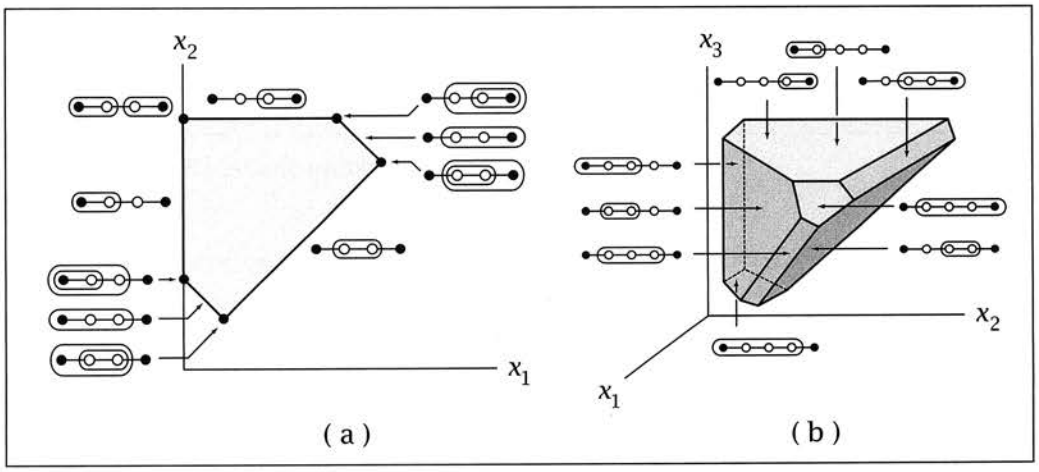


Figure 4. (a) Vertices and edges of K_4 labeled. (b) Facets of K_5 labeled.

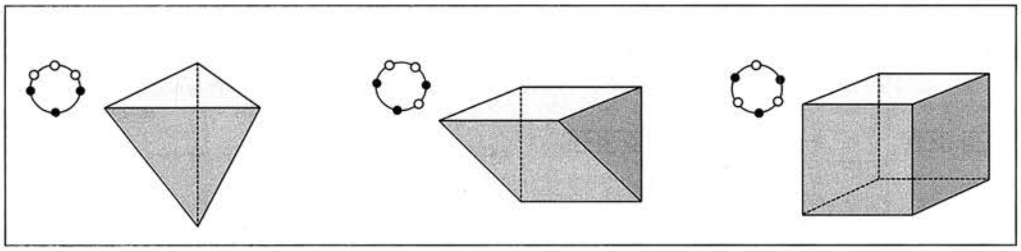


Figure 5. Three types of simplicial products with three particles.

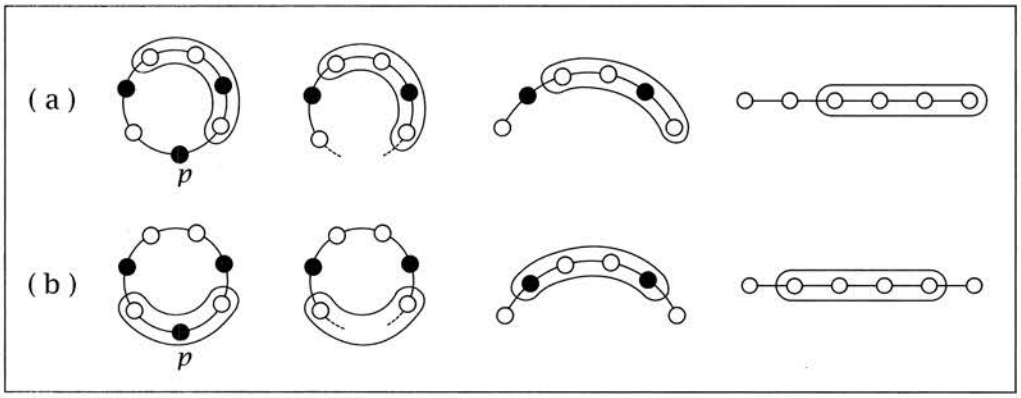


Figure 6. Bijection from $\mathfrak{B}(n)$ to $\mathfrak{A}(n)$.

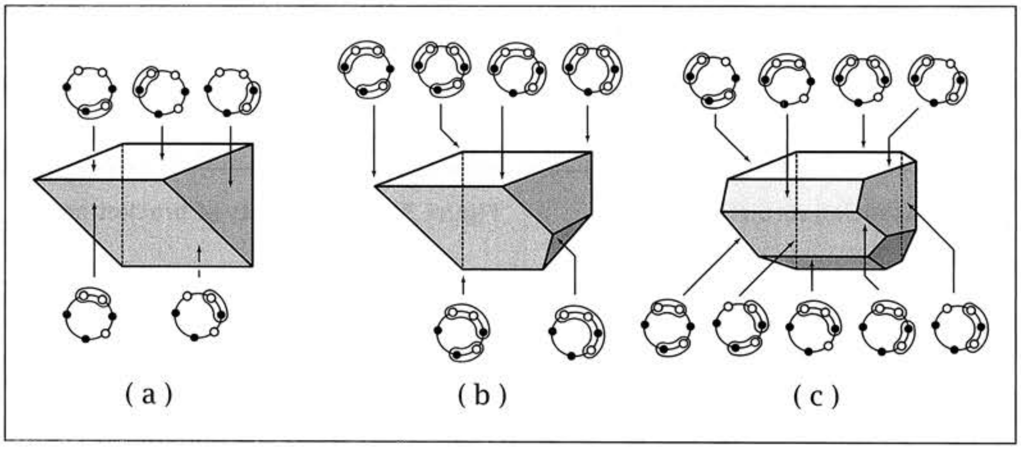


Figure 7. Truncation and labeling of $\Delta_2 \times \Delta_1$.

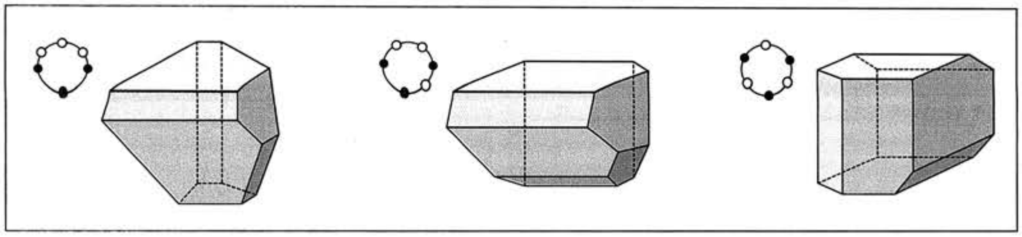


Figure 8. Iterated truncations of polytopes resulting in K_5.

$$0 < x_1 < x_2 = x_3 = x_4 < x_5 < x_6 = 1.$$

We call such a diagram a bracketing. *Figure 1 depicts Δ_2 and Δ_3 along with a labeling of vertices and edges.*

The associahedron is a convex polytope originally defined by Stasheff [12] for use in homotopy theory in connection with associativity properties of H-spaces. It continues to appear in a vast number of mathematical fields, currently leading to numerous generalizations.

Definition 2. *Let $\mathfrak{A}(n)$ be the poset of bracketings of a path with n nodes, ordered such that $a \prec a'$ if a is obtained from a′ by adding new brackets. The* associahedron K_n *is a convex polytope of dimension $n - 2$ whose face poset is isomorphic to $\mathfrak{A}(n)$.*

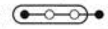
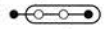
Example 3. *Figure 2 shows the two-dimensional K_4 as the pentagon. Each edge of K_4 has one set of brackets, whereas each vertex has two. Figure 4(b) depicts K_5 with only the* facets *(codimension one faces) labeled here.*

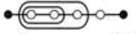
Two bracketings are *compatible* if the brackets of the superimposition do not intersect. Figure 3 shows an example of two compatible bracketings, (a) and (b). It follows from the definition of K_n that two faces are adjacent if and only if their bracketings are compatible. Furthermore, the face of intersection is labeled by the superimposed image (c).

A well-known construction of the associahedron from the simplex via truncating hyperplanes is given in the appendix of [13]. A reformulation from the perspective of configuration spaces is as follows:

Construction 1. *Choose the collection C of codimension k faces of the n-simplex $B_n\langle I_2\rangle$ which correspond to configurations where $k+1$ adjacent particles collide. Truncating elements of C in increasing order of dimension results in K_{n+2}.*

Remark. *A proof of this construction using face posets and bracketings in a general context of graphs is given in [1, §5].*

Example 4. *Figure 4(a) shows K_4 after truncating the two vertices*  *and*  *of Δ_2 given in Figure 1. Each vertex is now replaced by a facet given the same labeling as the original vertices. However, the new vertices introduced by shaving are labeled with nested parentheses, seen as the superimposition of the respective diagrams. Similarly, Figure 4(b) displays K_5 with facets diagrams after first shaving two vertices and then three edges of Δ_3. Compare this with Figure 1.*

This construction of K_n from the simplex is the real *Fulton-MacPherson* [6] compactification of the configuration space $B_n(I_2)$. We denote this as $B_n[I_2]$. Casually speaking, one is not only interested in when k adjacent particles collide but in resolving that singularity by ordering the collisions. For example,  not just conveys that the three particles have collided but that the first two particles collided before meeting with the third.

Remark. *In the original closed simplex, the number of equalities (collisions) corresponds to the codimension of the cell. After the compactification, the codimension is given by the number of brackets.*

Products of Simplices

We extend the notions above to triple products of simplices. In doing so, we see new combinatorial constructions of the associahedron. Let S_3 denote a circle with three distinct fixed particles. The space $B_n\langle S_3\rangle$ is combinatorially equivalent to the product of three simplices $\Delta_i \times \Delta_j \times \Delta_k$, with $i+j+k=n$. Indeed, the different types of simplicial products depend on how the n particles are partitioned among the three regions, each region defined between two fixed particles. Note that each configuration of k particles that fall between two fixed particles gives rise to the k-simplex $B_k\langle I_2\rangle$.

Example 5. *There are three possibilities when $n=3$: the simplex Δ_3, the prism $\Delta_2 \times \Delta_1$, and the cube $\Delta_1 \times \Delta_1 \times \Delta_1$ as presented in Figure 5.*

Construction 2. *Let $\mathfrak{B}(n)$ be the poset of bracketings of S_3 with $n-2$ additional nodes partitioned into the three regions, where no bracket contains more than one of the three marked nodes of S_3. Order them such that $b \prec b'$ if b is obtained from b' by adding new brackets. The face poset $\mathfrak{A}(n)$ of K_n is isomorphic to $\mathfrak{B}(n)$.*

Choose any one of the three fixed particles of S_3 and call it p. The particles of $S_3 - p$ can be viewed as n particles on the line. If a bracket does not contain p, preserve this bracketing on the line; see Figure 6(a). If a bracket does contain p, choose the bracket on the line that encloses the complementary set of particles; see Figure 6(b). This is a bijection of posets, since a bracket on S_3 can contain at most one fixed particle.

Remark . *Each partition of the $n-2$ nodes in S_3 gives rise to a different poset that is isomorphic to $\mathfrak{A}(n)$.*

We look at the compactification $B_n[S_3]$. Analogous to Construction 1, we specify certain faces of $\Delta_x \times \Delta_y \times \Delta_z$ to be truncated, namely the codimension k faces where $k+1$ adjacent particles collide. Indeed, each facet of the polytope $B_n[S_3]$ will correspond to a unique way of adding a bracket around the $n+3$ particles (n free and 3 fixed) in S_3. The restriction will be that no bracket will include more than one fixed particle, for this would imply that the fixed particles inside the bracket would be identified.

Example 6. *Figure 7(a) shows the prism in Figure 5 with labeling of the top dimensional faces. Figure 7(b) shows the labeling of the vertices, along with the new facet obtained by shaving a vertex (codimension three) where four adjacent particles collide. Similarly, part (c) is the labeling of the edges, along with the truncation of three of them. Notice that the resulting polytope is combinatorially equivalent to K_5.*

Construction 3. *Choose the collection of codimension k faces of $\Delta_x \times \Delta_y \times \Delta_z$ which correspond to configurations where $k+1$ adjacent particles collide. Truncating elements of this collection in increasing order of dimension results in $K_{x+y+z+2}$.*

An n-polytope is *simple* if every k-face is contained in $n-k$ facets. Since $\Delta_x \times \Delta_y \times \Delta_z$ is simple, truncating a codimension k face F replaces it with a product $F \times \Delta_{k-1}$. Label the faces of $F \times \Delta_{k-1}$ with superimposition of neighboring faces. Truncating all elements produces a face poset structure isomorphic to $\mathfrak{B}(n)$. Then use Construction 2.

Corollary 7. *Let $p_k(n)$ be partitions of n into exactly k parts. There are*

$$p_3(n-3) + p_2(n-2) + 1$$

different ways of obtaining K_n from iterated truncations of simplicial products.

Indeed, for each triple product of simplices there exists a method to obtain the associahedron from iterated truncations of faces. Figure 8 shows K_5 from truncations of the three polytopes in Figure 5. Figure 13 displays the *Schlegel diagrams* of four 4-polytopes: the (a) 4-simplex, (b) tetrahedral prism, (c) product of triangles, and (d) product of triangle and square. Each is truncated to (combinatorial equivalent) K_6 associahedra, each with seven K_5 and seven pentagonal prism facets.

The Braid Arrangement

We relate the combinatorial structure of the associahedron to a tiling of spaces. This yields an elegant framework for associating Coxeter complexes to certain moduli spaces. We begin with some background [2]. The symmetric group $\mathbb{S}_{n+2}$ is a finite reflection group acting on $\mathbb{R}^{n+2}$ as reflections (ij) across the hyperplanes $\{x_i = x_j\}$, forming the *braid arrangement* of hyperplanes $\mathcal{H}$. The *essential* subspace under the action of $\mathbb{S}_{n+2}$ is the hyperplane V^{n+1} defined by $\Sigma x_i = 0$. This space is tiled by simplicial cones, defined by $n+1$ inequalities

$$x_{i_1} \leq x_{i_2} \leq \cdots \leq x_{i_{n+1}} \leq x_{i_{n+2}}. \tag{2}$$

Let $\mathbb{S}V^n$ be the sphere in V^{n+1}. The braid arrangement gives these spaces a cellular decomposition into $(n+2)!$ chambers. Each chamber of $\mathbb{S}V^n$ is an n-simplex, defined by (2) where not all inequalities are equalities.[1]

Definition 8. *A* cellulation *of a manifold M is formed by gluing together polytopes using combinatorial equivalence of their faces, together with the decomposition of M into its cells.*

Proposition 9. *Let $C_n\langle\mathbb{R}\rangle$ denote the closure of $C_n(\mathbb{R})/\mathrm{Aff}(\mathbb{R})$. Then $C_n\langle\mathbb{R}\rangle$ has the same cellulation as $\mathbb{S}V^{n-2}$.*

Proof. Let $v = \langle v_1, \ldots, v_n\rangle \in C_n\langle\mathbb{R}\rangle$. Define the map $\varphi : C_{n+2}\langle\mathbb{R}\rangle \to \mathbb{S}V^{n-2}$ such that

$$\varphi(v) = \frac{\sum v_i \vec{a}_i}{|\sum v_i \vec{a}_i|}.$$

It is easy to show that φ is a homeomorphism. Since a codimension k face of both spaces is where exactly k equalities in $\langle v_1, \ldots, v_n\rangle$ occur, the cellulation naturally follows. □

Indeed, each simplicial chamber of $\mathbb{S}V^n$ corresponds to an arrangement of $n+2$ particles on an interval, resulting in $B_n\langle I_2\rangle$. A chamber of $\mathbb{P}V^n$, the projective sphere in V^{n+1}, identifies two antipodal chambers of $\mathbb{S}V^n$. Figures 9(a) and 9(b) depict the $n = 2$ case. Observe that quotienting by translations of $\mathrm{Aff}(\mathbb{R})$ removes the inessential component of the arrangement, scaling (by a factor of $s \in \mathbb{R}^+$) pertains to intersecting V^n with the sphere, and *dilating* (by a factor of $s \in \mathbb{R}^*$) results in $\mathbb{P}V^n$.

The collection of hyperplanes $\{x_i = 0 \mid i = 1, \ldots, n\}$ of $\mathbb{R}^n$ generates the *coordinate* arrangement. Let M be a manifold and $D \subset M$ a union of codimension one submanifolds which dissects M into convex polytopes. A crossing (of D) in M is *normal* if it is locally isomorphic to a coordinate arrangement. If every crossing is normal, then M is *right angled.* An operation which transforms any crossing into a normal crossing involves the algebro-geometric concept of a blowup.

Definition 10. *For a linear subspace X of a vector space Y, we* blow up *$\mathbb{P}Y$ along $\mathbb{P}X$ by removing $\mathbb{P}X$, replacing it with the sphere bundle associated to the normal bundle of $\mathbb{P}X \subset \mathbb{P}Y$, and then projectifying the bundle.*

Blowing up a subspace of a cell complex truncates faces of polytopes adjacent to the subspace. As mentioned above with truncations, a general collection of blowups is usually noncommutative in nature; in other words, the order in which spaces are blown up is important. For a given arrangement, De Concini and Procesi [4] establish the existence (and uniqueness) of a *minimal building set*, a collection of subspaces for which blowups commute for a given dimension and for which the resulting space is right angled.

For an arrangement of hyperplanes, the method developed by De Concini and Procesi compactifies their complements by iterated blowups of the minimal building set. In the case of the arrangement $X^n - C_n(X)$, their procedure yields the Fulton-MacPherson compactification of $C_n(X)$. We can view $\mathbb{P}V^n$ as a configuration space, where the codimension k elements of the minimal building set are the subspaces

$$x_{i_1} = x_{i_2} = \cdots = x_{i_{k+1}} \tag{3}$$

of $\mathbb{P}V^n$ where $k+1$ adjacent particles collide. Let $\mathbb{P}V^n_\#$ denote the space $\mathbb{P}V^n$ after iterated blowups along elements of the minimal building set in increasing order of dimension.

Theorem 11. [8] *$\mathbb{P}V^n_\#$ is tiled by $\frac{1}{2}(n+2)!$ copies of associahedra K_{n+2}.*

Indeed, this is natural, since the blowup of all codimension k subspaces (3) truncates the collection C of codimension k faces of the simplex defined in Construction 1. Figure 9(d) shows $\mathbb{P}V^2_\#$ tiled by 12 associahedra K_4.

A combinatorial construction of $\mathbb{P}V^n_\#$ is presented in [5] by gluing faces of the $\frac{1}{2}(n+2)!$ copies of associahedra. Associate to each K_{n+2} a path with

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[1] *The point where all equalities exist is at the cone point, which is not contained in the sphere.*

$n+2$ labeled nodes, with two such labelings equivalent up to reflection. Thus each face of an associahedron is identified with a labeled bracketing. A *twist* along a bracket reflects all the elements within the bracket (both labeled nodes and brackets).

Theorem 12. [5] *Two bracketings of a path with $n+2$ labeled nodes, corresponding to faces of K_{n+2}, are identified in $\mathbb{P}V^n_\#$ if there exists a sequence of twists along brackets from one diagram to another.*

Each element of the minimal building set corresponds to subspaces such as (3), where blowing up the subspace seeks to resolve the *order* in which collisions occur at such intersections. Crossing from a chamber through the blown-up cell into its antipodal one in the arrangement (from projectifying the bundle) corresponds to reflecting the elements $\{x_{i_1}, x_{i_2}, \dots, x_{i_{k+1}}\}$ in the ordering. Blowing up a minimal cell identifies faces across the antipodal chambers, with twisting along diagonals mimicking gluing antipodal faces after blowups.

Figure 10 shows a local tiling of $\mathbb{P}V^2_\#$ by K_4, with edges (in pairs) and vertices (in fours) being identified after twists. Notice that after twisting a bracket containing a fixed node, the new right- (or left-)most node becomes fixed by the action of $\mathrm{Aff}(\mathbb{R})$.

Remark . *This immediately shows $\mathbb{P}V^n_\#$ to be right-angled: a codimension k face of an associahedron of $\mathbb{P}V^n_\#$ has k brackets, with each twist along a bracket moving to an adjacent chamber. There are 2^k such possible combinations of twists, giving a normal crossing at each face.*

Kapranov's Theorem

We start with properties of the manifold before compactification.

Proposition 13. *Let $\mathbb{P}V^n_{\mathcal{H}}$ denote $\mathbb{P}V^n$ minus the braid arrangement $\mathcal{H}$. Then $\mathcal{M}_0^{n+3}(\mathbb{R})$ is isomorphic to $\mathbb{P}V^n_{\mathcal{H}}$.*

Proof. Let $(x_1, \dots, x_{n+3}) \in C_{n+3}(\mathbb{RP}^1)$. Since a projective automorphism of $\mathbb{P}^1$ is uniquely determined by the images of three points, we can take $x_{n+1}, x_{n+2}, x_{n+3}$ to $0, 1, \infty$, respectively. Therefore,

$$\begin{aligned}\mathcal{M}_0^{n+3}(\mathbb{R}) &= \{(x_1,\dots,x_n)\in(\mathbb{RP}^1)^n \mid x_i \neq x_j,\ x_i \neq 0,1,\infty\}\\ &= \{(x_1,\dots,x_n)\in(\mathbb{R}^1)^n \mid x_i \neq x_j,\ x_i \neq 0,1\}\\ &= \{(x_1,\dots,x_n)\in\mathbb{R}^n \mid x_i \neq x_j,\ x_i \neq 0,1\}.\end{aligned}$$

We construct a space isomorphic to $\mathbb{P}V^n_{\mathcal{H}}$: intersect $C_{n+2}(\mathbb{R})$ with the hyperplane $\{x_{n+2} = 0\}$ instead of the more symmetric hyperplane $\{\Sigma x_i = 0\}$ to obtain

$$\{(x_1, \dots, x_{n+1}) \in \mathbb{R}^{n+1} \mid x_i \neq x_j,\ x_i \neq 0\}.$$

We projectify by choosing the last coordinate to be one, resulting in

$$\{(x_1, \dots, x_n) \in \mathbb{R}^n \mid x_i \neq x_j,\ x_i \neq 0, 1\}.$$

This is isomorphic to $\mathbb{P}V^n_{\mathcal{H}}$, and the equivalence is shown. □

Since $\mathcal{M}_0^{n+3}(\mathbb{R})$ is isomorphic to the n-torus $(\mathbb{RP}^1)^n$ minus the hyperplanes $\{x_i = x_j, x_i = 0, 1, \infty\}$, it follows that

$$\mathcal{M}_0^{n+3}(\mathbb{R}) = C_n(S_3)$$

with the three fixed points identified to $0, 1, \infty$. As $\mathbb{P}V^n$ is tiled by simplices, the closure of $\mathcal{M}_0^{n+3}(\mathbb{R})$ is tiled by triple product of simplices, namely $B_n\langle S_3\rangle$. The compactification $\overline{\mathcal{M}}_0^{n+3}(\mathbb{R})$ is obtained by iterated blowups of $\mathcal{M}_0^{n+3}(\mathbb{R})$ along nonnormal crossings in increasing order of dimension [13, §3]. The codimension k subspaces

$$x_{i_1} = x_{i_2} = \cdots = x_{i_{k+1}}$$

and

$$x_{i_1} = x_{i_2} = \cdots = x_{i_k} = f,$$

where $f \in \{0, 1, \infty\}$, form the minimal building set, configurations where $k+1$ adjacent particles collide on S_3. Similar to $\mathbb{P}V^n_\#$, the blowup of all minimal subspaces truncates the chambers into associahedra as defined by Construction 3.

Although the closures of $\mathcal{M}_0^{n+3}(\mathbb{R})$ and $\mathbb{P}V^n_{\mathcal{H}}$ are clearly different (the torus T^n and $\mathbb{RP}^n$ respectively), Kapranov [8, §4] remarkably noticed that their compactifications are homeomorphic.[2] We give an alternate proof of his theorem.

Theorem 14. *$\overline{\mathcal{M}}_0^{n+3}(\mathbb{R})$ is homeomorphic to $\mathbb{P}V^n_\#$. Moreover, they have identical cellulation.*

Proof. Both $\overline{\mathcal{M}}_0^{n+3}(\mathbb{R})$ and $\mathbb{P}V^n_\#$ have the same number of chambers by Proposition 13. Each tile of the closure of $\mathcal{M}_0^{n+3}(\mathbb{R})$ corresponds to a triple product of simplices. Since the building set of $\mathcal{M}_0^{n+3}(\mathbb{R})$ corresponds to the faces of $B_n\langle S_3\rangle$ to be truncated in Construction 3, $\overline{\mathcal{M}}_0^{n+3}(\mathbb{R})$ is tiled by associahedra K_{n+2}, more precisely by $B_n[S_3]$. We still need to show this tiling is identical to that of $\mathbb{P}V^n_\#$.

As in Theorem 12, crossing a chamber through the blown-up cell into its antipodal one in the arrangement corresponds to reflecting the elements within a bracket of $B_n[S_3]$. This is encapsulated by the twisting operation on S_3, similar to $\mathbb{P}V^n_\#$. Finally, Construction 2 gives us the isomorphism of cellulations between $\overline{\mathcal{M}}_0^{n+3}(\mathbb{R})$ and $\mathbb{P}V^n_\#$. □

Example 15. *Figure 9(c) shows $\mathbb{P}V^2_{\mathcal{H}}$ tiled by open simplices and Figure 11(a) shows $\mathcal{M}_0^5(\mathbb{R})$, the*

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[2] *Kapranov actually proves a stronger result for the complex analog of the statement using Chow quotients of Grassmanians [9].*

2-torus minus the hyperplanes $\{x_1 = x_2, x_i = 0, 1, \infty\}$ *tiled by open simplices and squares. After minimal blowups, the resulting (homeomorphic) manifolds are* $\#^5\,\mathbb{RP}^2$ *in Figure 9(d) and* $T^2\,\#^3\,\mathbb{RP}^2$ *in Figure 11(b), both tiled by 12 associahedra* K_4.

Example 16. *Figure 12(a) shows* $\mathbb{RP}^3$ *along with five vertices (shaded orange) and ten lines (shaded blue) blown up, resulting in* $\mathbb{P}V_{\#}^3$. *All chambers have been truncated from the simplex to* K_5. *Figure 12(b) is the blowup of the 3-torus into* $\overline{\mathcal{M}}_0^6(\mathbb{R})$ *along three vertices (orange) and ten lines (blue). Notice the appearance of the associahedra as in Figure 8. The resulting manifolds are homeomorphic, tiled by 60 associahedra. The lower-dimensional moduli spaces* $\mathbb{P}V_{\#}^2$ *and* $\overline{\mathcal{M}}_0^5(\mathbb{R})$ *can be seen in the figures due to a product structure that is inherent in these spaces.*

Remark. *The iterated blowup of the minimal building set (that is, the Fulton-MacPherson compactification) is the key to this equivalence. Iterated blowups along the* maximal *building set (also known as the* polydiagonal *compactification of Ulyanov)—the collection of* all *crossings, not just the nonnormal ones—yield different manifolds for* $\mathbb{P}V_{\mathcal{H}}^n$ *and* $\mathcal{M}_0^{n+3}(\mathbb{R})$. *For example, the blowup of* $\mathbb{P}V_{\mathcal{H}}^2$ *is homeomorphic to* $\#^8\,\mathbb{RP}^2$ *tiled by 12 hexagons (permutohedra), whereas* $\mathcal{M}_0^5(\mathbb{R})$ *is homeomorphic to* $T^2\,\#^9\,\mathbb{RP}^2$ *tiled by 6 hexagons and 6 octagons.*

Conclusion

Although the motivating ideas of $\overline{\mathcal{M}}_0^n$ are now classical, the real analog is starting to develop richly. We have shown $\overline{\mathcal{M}}_0^n(\mathbb{R})$ to be intrinsically related to the braid arrangement, the Coxeter arrangement of type A_n. By looking at other Coxeter groups, an entire array of compactified configuration spaces has recently been studied, generalizing $\overline{\mathcal{M}}_0^n(\mathbb{R})$ from another perspective [1]. Davis et al. [3, §5] have shown these novel moduli spaces to be aspherical, where all the homotopy properties are completely encapsulated in their fundamental groups. Furthermore, both $\overline{\mathcal{M}}_0^n(\mathbb{R})$ and $\mathbb{P}V_{\#}^n$ have underlying operad structures: the properties of $\overline{\mathcal{M}}_0^n(\mathbb{R})$ are compatible with the operad of planar rooted trees [10], whereas the underlying structure for $\mathbb{P}V_{\#}^n$ is the mosaic operad of hyperbolic polygons [5].

This area is highly motivated by other fields, such as string theory, combinatorics of polytopes, representation theory, and others. We think that $\overline{\mathcal{M}}_0^n(\mathbb{R})$ will play a deeper role with future developments in mathematical physics. In his *Esquisse*, Grothendieck referred to $\overline{\mathcal{M}}_0^5$ as 'un petit joyau'. By looking at the real version of these spaces, we see structure determined by combinatorial tilings, jewels in their own right.

Acknowledgments. *We thank Jim Stasheff for continued encouragement and Mike Carr, Ruth Charney, and Mike Davis for helpful discussions.*

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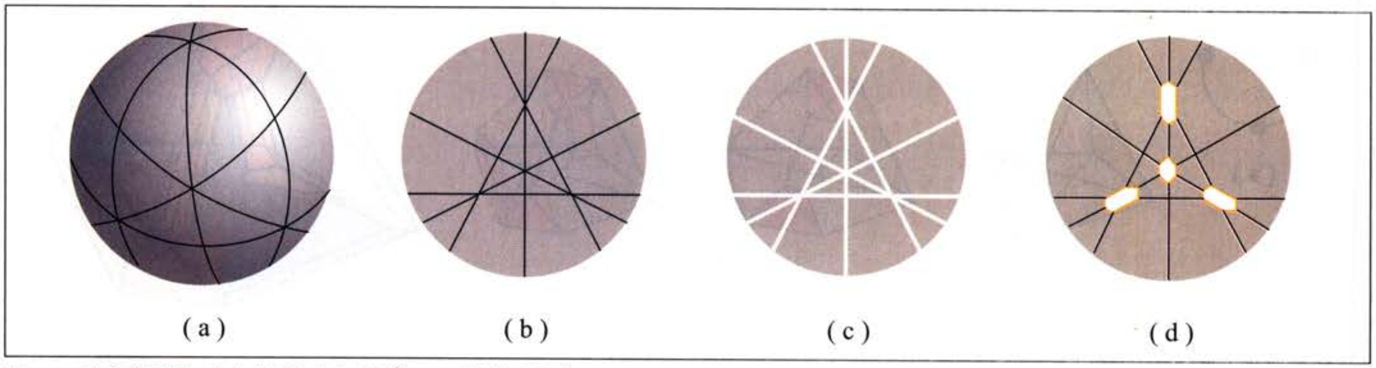

Figure 9. (a) $\mathbb{S}V^2$, (b) $\mathbb{P}V^2$, (c) $\mathbb{P}V^2_{\mathcal{H}}$, and (d) $\mathbb{P}V^2_{\#}$.

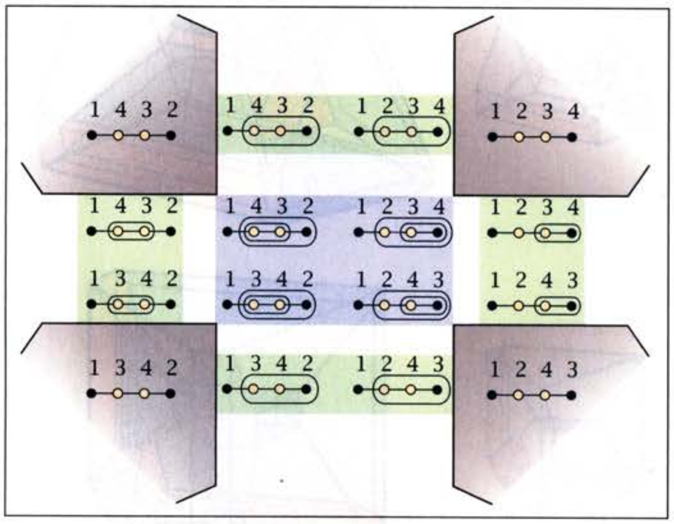

Figure 10. A local tiling of $\mathbb{P}V^2_{\#}$ displaying twisting.

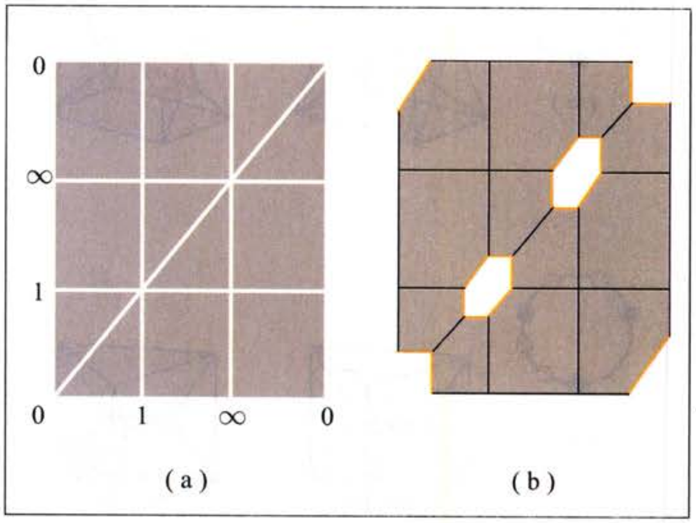

Figure 11. $\mathcal{M}^5_0(\mathbb{R})$ before and after compactification.

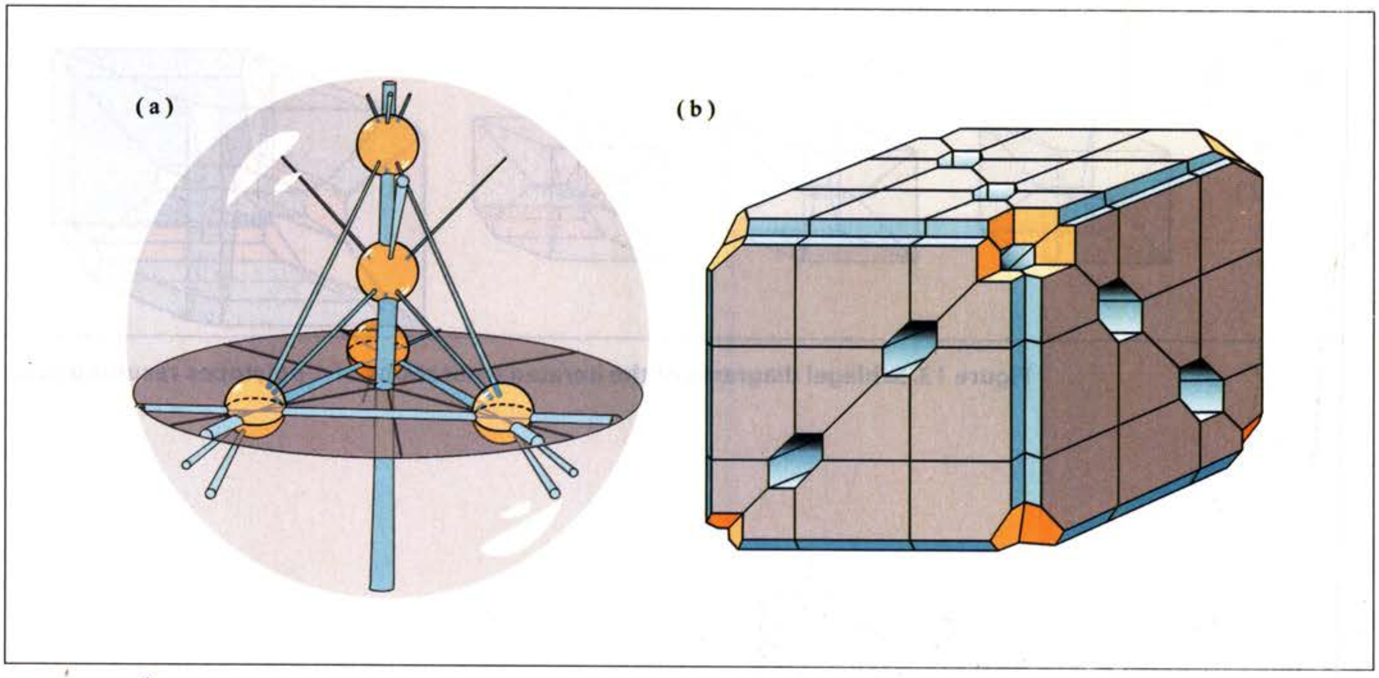

Figure 12. Iterated blowups of (a) $\mathbb{R}\mathbb{P}^3$ to $\mathbb{P}V^3_{\#}$ and (b) T^3 to $\overline{\mathcal{M}}^6_0(\mathbb{R})$ are both homeomorphic with a tiling by 60 associahedra.

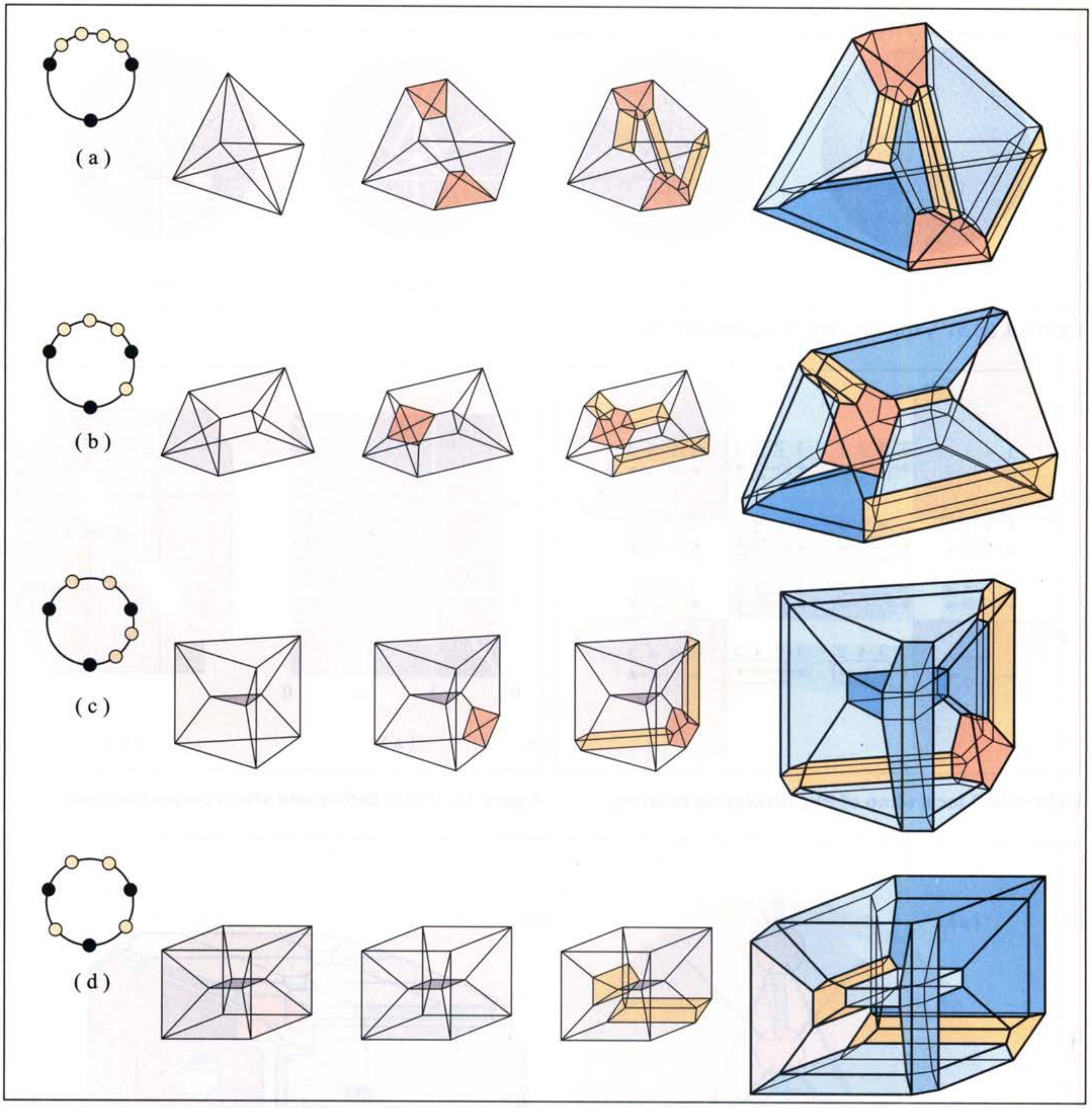

Figure 13. Schlegel diagrams of the iterated truncations of 4-polytopes resulting in K_6.

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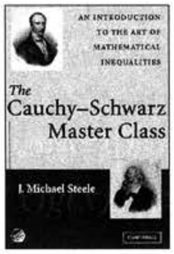

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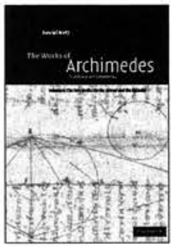

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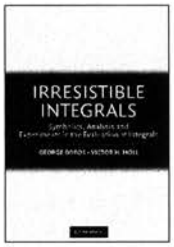

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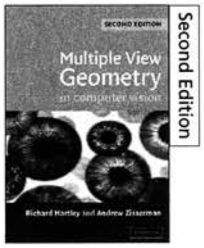

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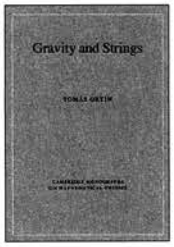

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WHAT IS... an Operad?

Jim Stasheff

An operad is an abstraction of a family of composable functions of n variables for various n, useful for the "bookkeeping" and applications of such families. Operads are particularly important and useful in categories with a good notion of "homotopy", where they play a key role in organizing hierarchies of higher homotopies. Operads as such were originally studied as a tool in homotopy theory, but the theory of operads has recently received new inspiration from homological algebra, category theory, algebraic geometry, and mathematical physics, especially string field theory and deformation quantization, as well as new developments in algebraic topology. The name *operad* and the formal definition appear first in the early 1970s in J. Peter May's *The Geometry of Iterated Loop Spaces*, but there is an abundance of prehistory. Particularly noteworthy is the work of Boardman and Vogt.

The most fundamental example of an operad is the *endomorphism operad* $\mathcal{E}nd_X := \{Map(X^n, X)\}_{n\geq 1}$, where for a set or topological space X, $\{Map(X^n, X)\}$ means the set or space of functions or continuous functions from the n-fold product of X with itself to X, together with the operations

$$\begin{aligned}\circ_i : Map(X^n, X)& \\ \times Map(X^m, X) &\longrightarrow Map(X^{n+m-1}, X)\end{aligned}$$

given, for $1 \leq i \leq n$, by

$$\begin{aligned}(f \circ_i g)&(x_1, \cdots, x_{m+n-1}) \\ &= f(x_1, \cdots, x_{i-1}, g(x_i, \cdots, x_{i+m-1}), x_{i+m}, \cdots).\end{aligned}$$

In the endomorphism operad $\mathcal{E}nd_X$ there are easily discovered relations involving iterated $\circ_i$-operations and the symmetric group Σ_n actions on the X^ns. For example,

$$\begin{gathered}(f \circ_i g) \circ_j h = f \circ_j (g \circ_{i-j+1} h) \\ \text{for } j \leq i \leq j + n - 1\end{gathered}$$

if g is a function of n variables, since only the name of the position for the insertion is changed.

An *operad* $(\mathcal{O}, \circ_i)$ consists of a collection $\{\mathcal{O}(n)\}_{n\geq 1}$ of objects and maps $\circ_i : \mathcal{O}(m) \times \mathcal{O}(n) \to \mathcal{O}(m + n - 1)$ for $m, n \geq 1$ satisfying the relations manifest in the example $\mathcal{E}nd_X$.

May's original definition corresponds to simultaneous insertions into all possible positions of inputs into $f \in Map(X^n, X)$. In most examples, the structures are "manifest" without appeal to the technical definitions; as Frank Adams used to say, to operate the machine, it is not necessary to raise the bonnet (look under the hood).

It helps to see graphic examples of operads. Two kinds that are particularly important are the tree operads and the little cubes (or disks) operads.

Let $\mathcal{T}(n)$ be the set of (nonplanar) trees with 1 root and n leaves labeled (arbitrarily) 1 through n. The collection $\mathcal{T} = \{\mathcal{T}(n)\}_{n\geq 1}$ of sets of trees forms an operad by grafting the root of g to the leaf of f labeled i, as in Figure 1.

The *little n-cubes operad* $C_n = \{C_n(j)\}_{j\geq 1}$, where $C_n(j)$ consists of an ordered collection of j n-cubes linearly embedded in the standard n-dimensional unit cube I^n with disjoint interiors and axes parallel to those of I^n. The operations are given as indicated in Figure 2.

Just as group theory without representations is rather sterile, so operads are best appreciated by their representations, known as (varieties of) algebras, especially algebras with higher homotopies.

An *algebra A over an operad* $\mathcal{O}$ "is" a map of operads $\mathcal{O} \to \mathcal{E}nd_A$. This is just a compact way of saying that an algebra A has a coherent system of maps $\mathcal{O}(n) \times A^n \to A$.

A major motivation for the development of operads was the desire to have a *homotopy invariant* characterization of based loop spaces and iterated loop spaces. Precisely such coherent systems of higher homotopies provided the answers. For based loop spaces, the operad in question, $\mathcal{K} = \{K_n\}_{n\geq 1}$, consists of the polytopes known as *associahedra*. The usual product of based loops is only homotopy associative. If we fix a specific associating homotopy and consider the five ways of parenthesizing the product of four loops, there results a pentagon whose edges correspond to a path of loops (Figure 3). (Compare

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Figure 2 in the article by Devadoss in this issue of the *Notices*.) From the leftmost vertex to the rightmost, consider the two paths of loops across the top or around the bottom. The pentagon can be filled in by a family of such paths from left to right corresponding to further adjustment of parameters.

The associahedron K_n can be described as a convex polytope with one vertex for each way of associating n ordered variables, that is, ways of inserting parentheses in a meaningful way in a word of n letters. The edges correspond to a single application of an associating homotopy. For K_5 see Figure 4 of the article by Devadoss in this issue of the *Notices*; a rotating image is available at `http://igd.univ-lyon1.fr/home/chapoton/stasheff.html`.

The cellular structure of the associahedra is well described by planar rooted trees, the vertices corresponding to binary trees and so forth. The facets are all products of two associahedra of lower dimension, and specific imbeddings can be given to play the role of the $\circ_i$ operations as in an operad. An *A_∞-space* is a space Y which admits a coherent family of maps

$$m_n : K_n \times Y^n \to Y$$

so that they make Y an algebra over the operad (without Σ_n-actions) $\mathcal{K} = \{K_n\}_{n \geq 1}$. The main result is:

A connected space Y (of the homotopy type of a CW-complex) has the homotopy type of a based loop space ΩX for some X if and only if Y is an A_∞-space.

Homotopy characterization of iterated loop spaces $\Omega^n X_n$ for some space X_n required the full power of the theory of operads with the symmetries.

A connected space Y (of the homotopy type of a CW-complex) has the homotopy type of an n-fold loop space $\Omega^n X_n$ for some space X_n if Y admits a coherent system of maps $C_n(j) \times Y^j \to Y$.

Although introduced originally in the category of topological spaces, operads were available almost immediately for chain complexes. The analog of an A_∞-space is an *A_∞-algebra,* and there is a Lie analog, an *L_∞-algebra.* These two special cases of "higher homotopy algebras" are particularly important in mathematical physics: A_∞ for open string field theory and L_∞ for closed string field theory and for deformation quantization. The operad for L_∞-algebras is given a very nice and physically relevant geometric interpretation in terms of a real compactification of the moduli space of Riemann spheres with punctures; see the article by Devadoss in this issue of the *Notices.*

One reason for the explosive development of operad theory in the 1990s was the introduction of operadic structures in topological field theories, e.g. CFTs (conformal field theories) and SFTs (string field theories), which in turn was inspired by the importance of moduli spaces of Riemann surfaces with punctures or boundaries (or other decorations) in these physical theories. The little j-disks operad $\mathcal{D}_j$ has a definition quite parallel to that of the little j-cubes operad. Using disks has the advantage of extending nicely to little disks holomorphically embedded in a Riemann surface Σ_g of genus g, leading to a more complicated and subtle notion of a *modular operad.*

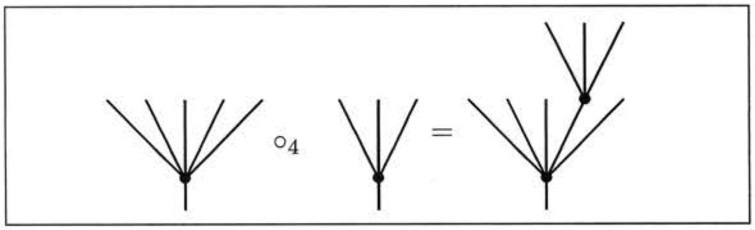


Figure 1. Grafting with the leaves numbered from left to right.

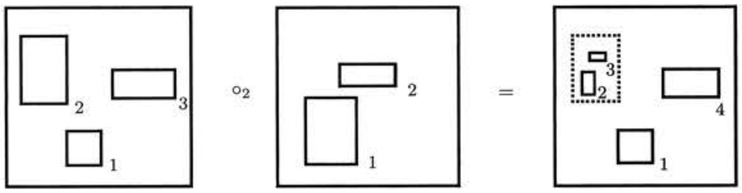


Figure 2. The little 2-cubes operad.

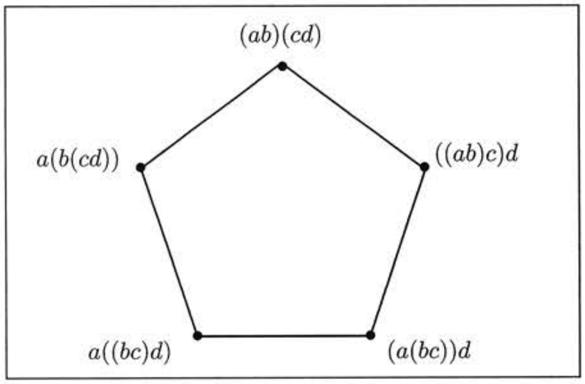


Figure 3. The associahedron K_4.

Also of importance for applications is the notion of an *A_∞-category.* These have been used by Fukaya for remarkable applications to Morse theory and Floer homology and by Batanin and by May in higher category theory. More recently, they play a role in string and D-brane theory and homological mirror symmetry.

For a reasonably up-to-date introduction and survey, consider [MSS02]. Two particularly important original works are [BV73] and [May72].

Further Reading

[BV73] J. M. Boardman and R. M. Vogt, *Homotopy Invariant Algebraic Structures on Topological Spaces,* Lecture Notes in Math., vol. 347, Springer-Verlag, 1973.

[May72] J. P. May, *The Geometry of Iterated Loop Spaces,* Lecture Notes in Math., vol. 271, Springer-Verlag, 1972.

[MSS02] Martin Markl, Steve Shnider, and Jim Stasheff, *Operads in Algebra, Topology and Physics,* Math. Surveys Monogr., vol. 96, Amer. Math. Soc., Providence, RI, 2002.

Book Review

A Sometimes Funny Book Supposedly about Infinity

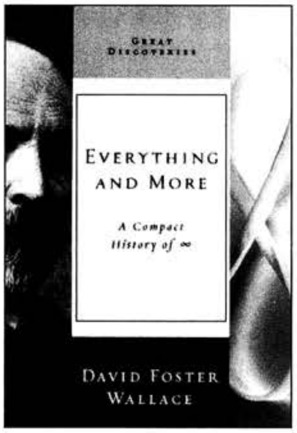
A Review of *Everything and More*

Reviewed by Michael Harris

Everything and More
David Foster Wallace
W. W. Norton & Company, 2003
320 pages, $23.95, ISBN 0-393-00338-8

Exalted, perhaps, in the wake of the World Trade Center attack, and suspecting, probably, that the American population would be satisfied with no response that fit within the limits of human comprehension, "someone, somewhere" in the Pentagon—the quotation is from Donald Rumsfeld—proposed "Infinite Justice" in late 2001 to designate the imminent campaign in Afghanistan. It was soon pointed out that many people, not least among those for whom the campaign was intended as an object lesson, considered infinity a divine prerogative, and the title was scrapped in favor of "Enduring Freedom". Instead of a guarantee both mathematical and eschatological, the world would have to settle for a pretty good insurance policy.

In the interim, more than one skeptic[1] had time to note the initial designation's inadvertent echo of *Infinite Jest*. It says something about our author's standing in American letters, at least among the wired, that the reference was not to Shakespeare's Poor Yorick, but rather to the title of David Foster Wallace's 1996 novel. On everybody's Ten Best list, qualified as "world-historical" by Frederic Jameson,[2] the 1,079-page *Infinite Jest* (IJ) propelled Wallace (DFW) immediately—and deservedly—to the front rank of American writers. Alongside his fiction, DFW has developed an intensely original and provocative style as essayist and often profound observer of contemporary U.S. culture. His best essays of the 1990s are collected in *A Supposedly Fun Thing I'll Never Do Again* (ASFTINDA), the very first page of which reports Wallace's adolescent "jones for mathematics". In between two collections of short stories, DFW has taken the time to write *Everything and More* (E&M), ostensibly about the events leading up to and the circumstances surrounding Georg Cantor's creation of his theory of infinite sets.



Wallace, future classic, will have his literary biographers, who will probably have little patience with the professional mathematician who objects to E&M on the grounds that it not only lacks a clear sense of direction (try figuring out what happens in IJ without a guide) but is laced through and through with blunders of every magnitude. It does not help that the two most strongly negative reviews of E&M thus far[3] were written by authors of what sympathetic biographers might construe as rival

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I thank Boban Velicković for a critical reading of E&M's sections on set theory, and Jordan Ellenberg for showing me an early manuscript of his review of E&M in Seed.

books about infinity. The returning exile discovers that popular books about infinity are already available in his home market. Rather a lot of them, it turns out. Yet another one—Brian Clegg's *Infinity: The Quest to Think the Unthinkable*—appeared almost simultaneously with E&M, and the two books were reviewed together in the *Guardian* by the eminent critic Frank Kermode.

Though there seems to be no limit to the demand for such books, a good chunk of the table of contents seems predetermined, a fact which may help you write your own book on infinity and which may in itself constitute an *a priori* proof of the existence of infinity.[4] Nevertheless, each new entry in the field needs to establish its distinctive brand identity. E&M is the first in a series called Great Discoveries, a joint venture between W. W. Norton and New York *literato* James Atlas. Many sorts of greatness sit comfortably on Atlas's shoulders: he piloted the series Great Lives, devoted to Alexander-level greatness, at Viking Penguin, and now his new outlet, Atlas Books,[5] has plans for a joint partnership called Eminent Lives with HarperCollins[6] (featuring Alexander himself); another partnership with W. W. Norton (and Profile Books in the UK) entitled Enterprise: Great Innovations in Business;[7] and Great Discoveries, dedicated to science.

The common feature of all these celebrations of greatness is the pairing of "today's top writers"[8] with subjects indisputably great. "David Foster Wallace, for example, has a real following, so this book will be embraced by his fans," according to Ed Barber, senior editor at Norton.[9] Barber guessed right: when I checked about one month after the book's release, E&M was listed 190th among Amazon's bestsellers. In early November it was prominently displayed in at least two East Coast airport bookshops. Three months later it is still in the airports, is in the respectable 3,000s on Amazon, and graces front tables in bookstores around Harvard Square and beyond.

With answers like this, questions are clearly beside the point. One should not dismiss E&M on the grounds of mercenary considerations alone, however. In the universe of Wallace's IJ it is not merely public-domain concepts like Great Discoveries but time itself, or at least the calendar, that has been branded, and one should assume this author is keenly sensitive to the dangers of being turned into a brand name himself. And the very existence of a series like Great Discoveries poses a question that is particularly acute for mathematicians: Is it possible to write a book about our subject that is not only comprehensible and accurate in the essentials but also has literary merit? Can "the narrative approach to science"[10] work for mathematics? Occasionally one comes across a readable and reliable mathematical popularization that is also well written. But for an experimental writer like DFW, the stakes, and therefore the hopes, are even greater: creation of a new literary genre within what Wallace calls "pop technical writing", in which the sense and depth of mathematics can be expressed creatively and readably with minimal loss.

One problem is that mathematical truth is rarely graceful when transcribed into natural language. Wallace makes this point explicitly in several passages in E&M: "...some technical words have highly specific denotations that no synonym can capture. Which means that, especially respecting certain high-tech proper nouns, abbreviation is the only way to achieve any kind of variation at all" (p. 3). Not every reader will find Wallace's abbreviations graceful, in or out of context, but the use of abbreviations and invented acronyms (often left to the reader to figure out in his other books; here he provides a glossary)[11] is an immediately recognizable feature of his style and contributes to its characteristic fusion of high and low cultures and of good and bad taste. This sort of ambivalent irreverance for high cultural traditions is familiar from alternative newspapers like the *Village Voice* and *LA Weekly* and the ambiguous status of rock critics and comic strip artists, for example; DFW himself has associated it with TV. The jury is out on whether this makes DFW a "postmodern" author, but it does make him a natural candidate for inventing a pop mathematics writing that would be to university mathematics as rock criticism is to symphonic music, and it is why I volunteered for this assignment. Among other qualities distinguishing Wallace from most of his post- (or post-post-?) modern contemporaries are his breadth of knowledge and interest, frequently described as "encyclopedic", and a brilliant talent for pastiche, displayed to great effect in IJ. He also has his share of idiosyncracies: his combination of a professorial tone[12] that brooks no contradiction[13] with deflationary words like "basically", "pretty much", "sort of", "stuff", or "shit"[14] that create the illusion of a conversation; a prodigious use of run-on sentences; the aforementioned acronyms; and especially the profusion of footnotes that supplement and in some cases contradict the main narrative.[15]

DFW places his book in its contemporary pop cultural context when he announces what kind of book about infinity it is not:

> The Mentally Ill Mathematician seems now in some ways to be what the Knight Errant, Mortified Saint, Tortured Artist, and Mad Scientist have been for other eras: sort of our Prometheus, the one who goes to forbidden places and returns with gifts we can all use but he alone pays for. (E&M, pp. 6–7)

He will instead concentrate on "Cantor's work and its context...so totally interesting and beautiful that there's no need for breathless Prometheusizing of the poor guy's life" (p. 7). "The aim is to discuss these achievements in such a way that they're vivid and comprehensible to readers who do not have pro grade backgrounds and expertise" (p. 1).

So that is the promise: "probably the most important novelist of his generation"[16] will engage the actual mathematical content of Cantor's theory of infinity while not ceasing to write in an avant-garde way. And instead of doing that, he begins with a long discussion of metaphysics and abstraction, on the grounds that infinity is "sort of the ultimate in drawing away from actual experience." Unlike many authors of recent popularizations, DFW makes a point of failing to develop mathematicians' characters, letting their work speak for itself. But in order to embed abstraction in lived experience, he is forced briefly to liberate the narrator from his primary role as professorial Virgil leading the reader's Dante to Cantor's paradise (from which Hilbert promised we would never be expelled) and to allow the narrator—i.e., himself—to adopt the posture of a human being beset by abstract thinking who suddenly wonders whether he is justified in believing that the floor will support him when he gets out of bed in the morning. To illustrate the pitfalls of induction from experience and belief in the reality of abstract ideas, he introduces the book's only other fully human character:

> There were four chickens in a wire coop off the garage, the brightest of whom was called Mr. Chicken. Every morning the farm's hired man's appearance in the coop area with a certain burlap sack caused Mr. Chicken to get excited and start doing warmup-pecks at the ground, because he knew it was feeding time. It was always around the same time t every morning, and Mr. Chicken had figured out that t (man + sack) = food, and thus was confidently doing his warmup-pecks on that last Sunday morning when the hired man suddenly reached out and grabbed Mr. Chicken and in one smooth motion wrung his neck and put him in the burlap sack and bore him off to the kitchen...[However,] Mr. Chicken appears...actually to have been correct—according to the Principle of Induction—in expecting nothing but breakfast from that $(n+1)$th appearance of man + sack at t. Something about the fact that Mr. Chicken not only didn't suspect a thing but appears to have been wholly justified in not suspecting a thing—this seems concretely creepy and upsetting.

I have quoted this passage at length as a representative sample of DFW's prose and of his informal approach to mathematical formalism, and to illustrate that his preoccupation with infinity here, and presumably in his fiction as well, is ultimately metaphysical. As it should be. Wallace distinguishes between what you "know" and what you really know. Mr. Chicken's predicament, and ours as finite beings, lies in the difference between the two. The metaphysical problem of infinity, and the reason for its historically controversial status in mathematics, is whether and by whom or what infinity can be really known and whether it really matters.[17] This problem has been central to Western philosophy throughout its history. Thus Augustine waxed indignant at the suggestion "that things infinite are past God's knowledge," Aquinas attempted to prove that "The existence of an actually infinite multitude is impossible," and Hume that "The capacity of the mind is not infinite."[18] In his most extensive philosophical justification of transfinite numbers, Wallace recalls, Cantor actually quoted Aquinas's arguments in detail and was particularly pleased to regard his own work as a refutation of these, "the weightiest" arguments ever advanced against infinity.[19] In one of his best passages, Wallace regrets, eloquently, that the controversy has been whitewashed in the standard math curriculum. "Rarely do math classes ever tell us whether a certain formula is truly significant, or why, or where it came from, or what was at stake....That we end up not even knowing that we don't know is the really insidious part of most math classes" (p. 52 and note 9).

The most carefully argued[20] section of E&M recapitulates the origins of the metaphysical problem of infinity in Zeno's paradoxes—"immeasurably subtle and profound," according to Bertrand Russell (quoted on p. 48), "nutcrunching" according to DFW—and their attempted resolution by Aristotle. Wallace asserts, I think correctly, that dismissing Zeno's dichotomy paradox by invoking the standard arguments for the summation of a convergent geometric series, in this case $\sum(1/2)^n = 1$, is "complex, formally sexy,[21] technically correct, and deeply trivial. Along the lines of 'Because it's illegal' as an answer to 'Why is it wrong to kill?'" (pp. 51–52).[22] His objections to Aristotle are more acerbic. Aristotle's response to Zeno's arguments, briefly, consisted in denying infinity anything more than a potential, as opposed to actual, existence. In DFW's reading, this was the "most efficient cause" behind the circumstance that "Europe had to wait nineteen centuries for the actual calculus, differential geometry, and analysis" (pp. 86–87). A few more centuries passed before Cantor finally placed *actual* infinite sets on a rigorous footing.

A two-sentence summary of the theme of E&M might be: Aristotle, for DFW, was content to "know" about infinity; after Cantor it became possible to know. Or did it?

"Real appreciation" of Cantor's innovations "requires understanding the concepts and problems that gave rise to set theory and made transfinite math significant in Hardy's sense" of "being connected, in a natural and illuminating way, with a large complex of other mathematical ideas."[23] And so, accompanied by the wraithlike honors high school math teacher "Dr. Goris", who probably really exists (and presumably presided over Wallace's "jones for mathematics"), though he serves several obvious structural functions in the narrative, DFW embarks with jolly ferocity on a 200-page historical and technical discussion of mathematical analysis.[24]

Rudy Rucker's judgment that "Nothing makes sense"[25] from this point on is surely too harsh, but this is where Wallace begins to get into serious trouble. Most mathematicians are aware that Cantor was led to develop set theory in the course of his work on pointwise convergence of trigonometric series. Cantor's Uniqueness Theorem asserted that two trigonometric series that converge pointwise everywhere on the unit interval to the same function have the same coefficients. His subsequent generalizations of this theorem replaced the condition "everywhere" by the complements of certain kinds of subsets of the real numbers, and in order to state his theorems he therefore requires theories of the real numbers and the subsets thereof. Though pointwise convergence of trigonometric series is a topic of little obvious metaphysical interest and is no longer as central a preoccupation as it was in Cantor's day,[26] Wallace spends nearly half his book preparing for, stating, and concluding (on pp. 233–234) with an irrelevant argument purporting to be a proof of, the most general form of Cantor's Uniqueness Theorem.[27]

The *New York Times* reviewer may have had these sections in mind when he admitted, in the course of a generally positive review, that it contains "a smattering of technical infelicities."[28] A mathematician reading E&M is unlikely to be so forgiving of DFW's blunders.[29] Some examples: The Weierstrass approach to limits is illustrated by a solution to Zeno's dichotomy paradox in which $\delta = 1$ for any ϵ (p. 190 ff). The Extreme Value Theorem is used to prove, Zeno be damned, that on any time interval $[t_1, t_2]$ the "time function" [*sic*] has an absolute minimum t_m which is "mathematically speaking, the *very next instant* after t_1" (p. 190). Although the continuum hypothesis is a principal theme and although it is correctly stated several times, DFW also claims three times that the continuum hypothesis is the assertion that the continuum has the cardinality of the power set of the natural numbers. A spurious distinction is drawn between "point-set theory" and "abstract set theory"; a presentation of Zermelo-Fraenkel set theory somehow fuses the Axiom Schema of Comprehension (which he calls the Limited Abstraction Principle) with the Axiom of Infinity; Kronecker is said to be most famous for his Delta Function ("which in some ways anticipates the binary math of modern digitation" [*sic*]); Dedekind is identified as a prototypical Platonist but also quoted to the effect that "Numbers are free creations of the human mind"; Cantor and Gödel are asserted to be respectively the most important mathematicians of the nineteenth and twentieth centuries (p. 5).

Journalist Jim Holt, writing in the *New Yorker*, pointed out a few of these infelicities and offered the curious hypothesis that Wallace is pulling our legs—E&M is actually "a sly send- up of pop technical writing." I would not put it past the author. Much of postmodern literary theory is concerned with a topic Wallace considers in ASFTINDA, that of undermining the authority of the author or of the narrative voice, and there is hardly a better way to do that than to make the author manifestly unreliable. DFW himself warns, without providing details, that there have been "infelicities permitted" (note 2, p. 126) in order to make the arguments accessible to readers with little background in mathematics. It may be no accident that the peculiar ranking of Cantor and Gödel mentioned above is followed immediately by the assertion that Hilbert was "the world's #1 mathematician" in the year 1900....

A characteristic feature of DFW's style in E&M is to disrupt narrative continuity (of which there is very little in IJ) with technical or historical digressions that he calls "interpolations". Here's an illustration. A college student and fellow passenger on the Boston subway spotted me reading E&M and asked me what I thought of the book. My response was substantially equivalent to the present review. She had also read the book, of which she understood very little, but "I assumed it was me." Reading IJ had also been hard work, so she had no reason to expect E&M to reveal its secrets without effort. True enough. Much that appears to be casual in IJ turns out to be crucial to understanding the structure as well as the author's intentions.[30] The same may conceivably be true of E&M, that the book only appears to be about the mathematics of infinity but that the author's real purpose is elsewhere: to tell a story or a joke whose point this reviewer has not worked hard enough to grasp. I have worried about this sometimes. But it has not kept me from getting out of bed in the morning.

One problem with Holt's interpretation, appealing as it is, is that what might be taken as DFW's artistic manifesto[31] comes out explicitly in favor of sincerity over hip irony and cynicism. With regard to mathematics, Wallace's attitude toward Dr. Goris is never short of reverential, and footnote 324 of IJ echoes the apparently sincere preface to E&M when the (admittedly ambiguous) character Pemulis calls mathematics "The nightlight on life's dark wall…." Besides, does a parody, or pastiche, really require a 100+-page discussion of convergent series and the like?

Will DFW's "real following" be upset to learn that the author may neither know nor "know" as much about trigonometric series as he appears to believe? Or that, by extension, his familiarity with optics, Quebecois dialect, and psychotropic drugs is not as extensive as the numerous footnotes to IJ suggest? Will they have any way of finding out?

The truth is probably less cunning than what Holt surmised. Wallace admitted on NPR's *Talk of the Nation*[32] that "I got into this as an exercise in something called 'technical writing', which is a kind of nonfiction where you're trying to take really abstract or technical stuff and make it clear and pretty." I can live with DFW's lack of expertise in analysis and set theory. The relatively flat and repetitious and for the most part neither clear nor pretty writing in his "exercise" is another matter. The jacket of ASFTINDA quotes the *New York Times Book Review* calling DFW "a dynamic writer of extraordinary talent…he lays his artistic self on the line with his incendiary use of language, at times seeming to rip the mundane and the unusual from their moorings…." This is absolutely appropriate as a description of IJ or ASFTINDA, which I unfortunately have no reason to quote in this review. E&M's jacket and most reviews contain similar praise. But prose-wise, the Mr. Chicken passage is as good as it gets. There are unusual metaphors, but they tend to be strained and unenlightening: in its cumulative nature, mathematics is "a towering baklava of abstractions and abstractions of abstractions" (p. 61), differential equations are compared to "integral calc on some sort of Class IV hallucinogen" (p. 151), Gödel is "modern math's absolute Prince of Darkness." The "exercise" may well be enough to satisfy hardcore Wallace fans who would not otherwise be motivated to read a book about any mathematical subject. That is arguably a good thing. It would be a shame, on the other hand, for a mathematically sophisticated reader to judge Wallace's style on the basis of E&M.

Most frustrating of all, though, is that the metaphysical concerns that fueled the first and best parts of the book get lost in DFW's attempt to make the technicalities "vivid and comprehensible." The author goes to great pains in the philosophical chapters to set a high standard for a solution of Zeno's paradoxes, considered relevant and philosophically problematic as recently as 2001.[33] He promises, quoting extensively from Bertrand Russell, that Cantor's creation of a consistent theory of actual infinities is such a solution. But by the time Wallace gets to the theory, Zeno has vanished, no justification is given for the earlier promises, and the concluding discussion of the Continuum Hypothesis seems to suggest that in fact the solution has come at the cost of deeper metaphysical problems: "…a world with no finite circumference… spins, now, in a new kind of all-formal Void" (p. 303).

Readers of IJ may recognize here a familiar pattern: a problem having been posed as central at the beginning of the narrative, the reader is surprised to discover that the book ends with no resolution in sight. Discussions of IJ insist on the book's absence of "closure", one reviewer of E&M claiming that "Wallace is on record as designing *Infinite Jest* to resemble…a 'Sierpinski gasket',"[34] presumably because most of the crucial plot developments are left to the reader as an exercise. Frustrating the reader's expectations is arguably characteristic of postmodern fiction, and it is understandable that DFW would go to considerable lengths to keep his book from degenerating into the sort of passive "entertainment" on which much of IJ is an apocalyptic meditation and that the Great Discoveries series threatens to offer.

Maybe pop mathematics has to end this way. Still, I am used to a symphony ending with a cadence and mathematics with Q.E.D. We have already run across Bertrand Russell, in the role of DFW's star witness to the Greatness of Cantor's discovery. An active reader of E&M may be expected to seek out the sources of the Russell quotations. Most come from a particularly militant 1901 defense of Russell's formalist position, concluding with the disconcerting hope that "pure thought may achieve, within our generation, such results as will place our time, in this respect, on a level with the greatest age of Greece." The logical positivists who attempted to realize this vision turned their backs on metaphysics. Near the end of E&M, metaphysics makes a brief return in a footnote, in an evocation of the "Prince of Darkness" and his incompleteness theorem: "It's this shattering of the belief that 100% abstraction = 100% truth that pure math has still not recovered from—nor is it yet even clear what 'recovery' here would mean" (p. 302, note 121).

Does DFW intend this as an ironic retrospective comment on Russell's hopes for pure thought? Russell's article is probably best known for the assertion that "mathematics may be defined as the subject in which we never know what we are talking about nor whether what we are saying is true."[35] At the end of E&M the reader is left wondering whether this wasn't what Wallace meant all along.

Notes

1. Exactly seventeen on the Web according to Google.

2. In "Fear and loathing in globalization", *New Left Review* **23** (September–October 2003).

3. R. Rucker, Infinite confusion, *Science* (January 16, 2004), 313a; A. Aczel, When good novelists do bad science, *The Globe and Mail* (Toronto) (January 3, 2004), D10.

4. The reviewer consulted five books about infinity for the general public, including E&M and Clegg's book. The numbers in brackets indicate how many of the five discussed or alluded to the topic in question: the Greek term *to apeiron* for infinity [3], Pythagoras [5], the irrationality of $\sqrt{2}$ [5], and the fate of Hippasus [5]; Zeno's paradoxes [5]; Aristotle and potential infinity [5]; Archimedes' "sand reckoner" [3]; Augustine's *City of God* [3]; Aquinas's *Summa Theologica* [4]; Nicholas of Cusa [4]; Galileo's *Two New Sciences* [5]; Cartesian coordinates [5]; Newton and Leibniz [5]; Berkeley's attack on infinitesimals ("ghosts of departed quantities)" [3]; Gauss's refusal to countenance actual infinities [5]; Bolzano's *Paradoxes of the Infinite* [5] and his pacifism [3]; the Riemann sphere (with its point at infinity) [3]; Weierstrass's skill at drinking and fencing [3]; the transcendence of pi [5]; Dedekind cuts [4]; Kronecker's rejection of infinity and his persecution of Cantor [4]; Cantor's theory of ordinals [4], his proof of the countability of $\mathbf{Q}$ [5], his diagonalization argument [5], "je le vois, mais je ne le crois pas" (written by Cantor, in French, in a letter to Dedekind concerning his proof of the commensurability of the line and the plane) [5], and the continuum hypothesis [5]; Peano's set-theoretic definition of the integers [5]; Russell's paradox [5]; Hilbert's Hotel [4]; Gödel's incompleteness theorem [5] and his starvation [5]; and Cohen's proof of independence of the continuum hypothesis [5].

5. According to `http://www.publishingtrends.com/copy/03/0302/0302bookview.html`, whose reliability I have no way to verify, one backer of Atlas Books is Roger Altman, former deputy Treasury secretary, now publisher of the *National Enquirer* and *Weekly World News*.

6. Bookseller.com, October 9, 2003; see `http://www.thebookseller.com/?pid=275&did=9125`. Atlas Books is located in the HarperCollins Building on 53rd Street in Manhattan. HarperCollins itself is a subsidiary of Rupert Murdoch's News Corp., along with Fox News, the *New York Post*, and the *Times Literary Supplement*.

7. `http://www.publishingnews.co.uk/pn/pno_ff2003news33.asp`.

8. From W. W. Norton press material accompanying my review copy of E&M, featuring advance praise by James Gleick, *New York Magazine*, and *Playboy*.

9. Quoted by Dalia Sofer in "The narrative approach to science", *Poets and Writers Magazine* online, `http://www. pw.org/mag/0309/newssofer2.htm`.

10. See last note.

11. Ubiquitous in E&M is IYI (If You're Interested), supposedly allowing DFW to pack at least two books into E&M, designed for readers with different degrees of mathematical knowledge. Some other random examples: D.B.P. (Divine Brotherhood of Pythagoras), V.I.R. (Vicious Infinite Regress), G.C.P.F.S. (General Convergence Problem of Fourier Series, used only once as far as I can tell).

12. Like most *Notices* readers, Wallace has spent nearly all his adult life as a professional academic.

13. An example: "The father of abstraction in mathematics: Pythagoras. The father of abstraction in philosophy: Plato." (E&M, p. 10).

14. The first time I have seen this word in a book of any kind about mathematics or, for that matter, in the AMS *Notices*.

15. There are 408 footnotes in E&M, numbered separately by chapter. The endnotes to IJ, some of them with their own footnotes, contain crucial plot information and run to 97 pages, or 8.99% of the total volume of the book.

16. Caleb Crain, *Boston Globe*, October 26, 2003.

17. Building on the results of Gödel and Turing—soon to be featured in the Great Discoveries series, by the way—on undecidability and his own work on algorithmic complexity, Gregory Chaitin has argued vigorously in several books for general readers that the distinction between knowing and "knowing" is still operative where the continuum is concerned. The French philosophers Jean Cavaillès and Jean-Toussaint Desanti wrote long and difficult books about the possibility of phenomenological knowledge (as opposed to "knowledge") of the continuum, given that purely logical knowledge is apparently excluded. In *Infinity and the Mind* (1982), on the other hand, Rudy Rucker proposes a number of ingenious ways finite beings like us might really know, and not merely "know", infinity but does not go so far as to argue that we could really know that we really know.

18. Augustine, in *City of God*, quoted in R. Rucker, op. cit., pp. 3–4; Aquinas, in *Summa Theologiae*, quoted in E&M, p. 93; Hume, in *A Treatise on Human Nature*, quoted by B. Clegg, op. cit., p. 219.

19. "Dies sind die beiden gewichstigsten Gründe, welche im Laufe der Zeiten gegen das Transfinitum vorgeführt worden sind...", G. Cantor, Mitteilungen zur Lehre vom Transfiniten, in *Gesammellte Abhandlungen* (Berlin: Springer-Verlag, 1932), pp. 378–439. The quotation is on p. 404, and DFW's recollection on p. 93 of E&M is not altogether accurate. Cantor considers his theory a response to two of Aquinas's arguments: one concerning enumeration, the second the "clear intention of the Creator." Perhaps understandably, DFW omitted to recall the latter. He also translates Aquinas's *multitudo* as "set", which looks anachronistic, though it may be a reasonable equivalent of Cantor's "Menge"; I am in no position to say.

20. Disclaimer: I am not competent to gauge the accuracy of DFW's account of Greek philosophy, and the last footnote suggests caution. I am pretty confident of this judgment nonetheless.

21. This curious use of the word "sexy", which recurs several times in E&M, should not be seen as a bit of unexpected good news for *Notices* readers who teach calculus; apparently it reflects a purely linguistic evolution rather than a significant cultural shift.

22. Trivial, perhaps, but not stupid; according to Max Black, "This kind of mathematical solution has behind it the authority of Descartes and [C. S.] Pierce and Whitehead," among others, though Black agrees that it does not "go to the heart of the matter." See Black's "Achilles and the tortoise", reprinted in *Zeno's Paradoxes* (W. Salmon, ed.), Hackett, 2001, p. 70.

23. The first part is from p. 43, the second a quotation on p. 42 from Hardy's *A Mathematician's Apology*.

24. Near the end of the 200 pages, DFW admits that "All you really need to get is a rough sense of how the Uniqueness Theorem leads Cantor into transfinite math" (p. 233, note 14).

25. In Rucker's review in *Science*; see note 3.

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26. On p. 44 of his *Fourier Series* (Springer-Verlag Graduate Texts in Mathematics, 1979), R. A. Edwards refers to "Dogged insistence on the pointwise interpretation of convergence."

27. "It's the hardest part of the book." Wallace, quoted in Crain, op. cit. On several occasions Wallace insists on the distinction between Fourier series and general trigonometric series, without making clear how they differ beyond saying that the former have Fourier coefficients, which are "so conceptually hairy that we plan to avoid them at almost any cost" (p. 116).

28. David Papineau, *New York Times Book Review*, November 16, 2003.

29. Had Atlas and Norton seen fit to send the manuscript to a mathematical reader before publication, most of these blunders could easily have been avoided, though occasionally at the cost of substantial rewriting. I note in this connection recurrent nervous allusions in E&M to unspecified time and space limitations.

30. See Stephen Burn, *David Foster Wallace's Infinite Jest: A Reader's Guide* (*Continuum*, 2003).

31. "E Unibus Pluram," in ASFTINDA.

32. On October 13, 2003. "I wince at the idea that there are mathematicians in the audience," said Wallace, "because I'm by no means an expert."

33. See Wesley C. Salmon, *Zeno's Paradoxes*, for important twentieth-century contributions to an understanding of Zeno's paradoxes and an extensive bibliography of relevant articles, (mainly) in English, current through 2001. For echoes in continental philosophy, see V. Tasić *Mathematics and the Roots of Postmodern Thought*, and my review in the August 2003 issue of the *Notices*.

34. Review by D. Kipen in the *San Francisco Chronicle*, November 18, 2003. Why not a Cantor set, I wonder?

35. B. Russell, Mathematics and the metaphysicians, from *Mysticism and Logic* (London: Longmans Green, 1918), pp. 74–96; reprinted in James R. Newman, *The World of Mathematics* (1956), quotations from p. 1590 and p. 1577. The article was originally published in 1901 as "Recent work on the principles of mathematics", *International Monthly* 4, 83–101.

The International Commission on Mathematical Instruction What? Why? For Whom?

Hyman Bass and Bernard R. Hodgson

Mathematics is an international—even universal—discipline, and this aspect finds institutional expression every four years in the International Congress of Mathematicians (ICM), where a world community of mathematicians assembles to report progress on shared problems and with a common technical language. But these things, which we now take for granted, were not always so. The "international movement" in mathematics took hold only at the end of the nineteenth century, the first congress being the 1897 ICM in Zürich. The body that now provides the international infrastructure for mathematics—for example, sponsoring the ICM's—is the International Mathematical Union (IMU),[1] an international nongovernmental and nonprofit scientific organization with the purpose of promoting international cooperation in mathematics. The members of the IMU are not individuals but countries, and the adhering (membership) entity in each member country is typically its Academy of Sciences or a professional organization of mathematicians. The IMU is known to mathematicians mainly indirectly through the publicly visible expressions of its work, like the ICM's and the awarding of the Fields Medals.

Our focus here is the International Commission on Mathematical Instruction (ICMI), the *mathematics education* counterpart to the IMU.

A Brief Bio of the ICMI

The International Commission on Mathematical Instruction[2] was founded at the fourth ICM held in Rome in 1908.[3] It was initiated to support a then widespread interest among mathematicians in school education. The Rome Congress adopted a resolution, submitted on the initiative of the American mathematician, teacher-educator, and historian of mathematics David Eugene Smith (1860–1944), creating an international commission with the initial mandate of making "a comparative study on the methods and plans of teaching mathematics at secondary schools" (quoted in [5, p. 13]). The idea of such an international commission had in fact been formulated by Smith himself three years earlier in the newly established journal *L'Enseignement Mathématique* (L'EM) in his response to a survey proposed by the editors on the "conditions to be satisfied by a complete—theoretical and practical—teaching of mathematics in higher institutions" [2].

The birth of the ICMI was not modest. The great German mathematician Felix Klein (1849–1925), for whom mathematics education was a deep and career-long interest, became its founding

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[1] `http://www.mathunion.org/`.

[2] *Historical information about the ICMI can be found in the ICMI 75th-anniversary paper [3] by Howson as well as in Lehto's recent book [5] on the history of the International Mathematical Union.*

[3] *So we are close to the first centenary of the ICMI, to be celebrated in Italy in 2008.*

president, while the first secretary-general was Henri Fehr (1870–1954) from Switzerland, one of the co-founders of L'EM.[4] The initial ICMI mandate, an international comparative study, ultimately became a massive six-year project producing 187 volumes containing 310 reports from 18 countries [5, p. 14]. Later ICMI presidents—thus far always research mathematicians—include such figures as Jacques Hadamard (from 1932 to the war), Marshall H. Stone (1959–62), André Lichnerowicz (1963–66), Hans Freudenthal (1967–70), Hassler Whitney (1979–82), and Jean-Pierre Kahane (1983–90), and Miguel de Guzmán (1991–98).[5] So the interest and productive engagement of serious research mathematicians with school mathematics education, even at the international level, has a long and substantial, albeit uneven, history.

A small but significant place for mathematics education was reserved at the ICM's, in a section initially called "Teaching and History of Mathematics". It was in this section at the 1900 ICM in Paris that David Hilbert gave the talk "Mathematical problems" that shaped much of twentieth-century mathematics. As the history of mathematics later acquired a section of its own, the name changed to "Teaching and Popularization of Mathematics" and most recently to "Mathematics Education and Popularization of Mathematics", reflecting the broader nature of the field.

Over time, as the mission of general education expanded (more advanced knowledge, for more people), the needs and complexity of mathematics education grew as well, leading to the development in due course of corresponding communities of both practicing professionals and scholars. The small venue afforded by the one section of the ICM's became inadequate for the communication of problems and ideas in this expanded domain. This led ICMI president Hans Freudenthal to organize the first International Congress on Mathematical Education (ICME) in Lyon in 1969. These ICME's have since evolved into quadrennial congresses in years divisible by four,[6] the next one to be ICME-10 in Copenhagen, July 4–11, 2004, where we expect some 3,500 participants, including a significant number of mathematicians. (More on ICME-10 below.)

Connecting Mathematics and Mathematics Education

Mathematics education and *mathematics*, though obviously linked, are fundamentally different as domains of practice and scholarship. Their main historical intersection has been the induction and advanced mathematical preparation of mathematical researchers and scientists, a small but now growing fraction of the population served by school education, and this primarily at postsecondary levels. While most mathematicians teach, mathematics education treats teaching much more seriously as a professional practice, requiring dedicated training and certification. Theories of learning and of assessment play much more prominent roles, as does curriculum analysis. And these have become as well multidisciplinary domains of mathematics education research, using a variety of methods, many of them unfamiliar to most mathematicians.

So how are mathematics and mathematics education, as domains of knowledge and as communities of practice, now linked, and what could be the most natural and productive kinds of connections? The ICMI represents one historical, and still evolving, response to those questions at the international level. First of all, the ICMI, now formally constituted as a commission of the IMU (see the next section), is thus structurally tied to mathematics. In fact, nominally and in terms of governance, the ICMI is subordinate to mathematics. (Recall, for example, where the presidents of the ICMI have come from.) This is, on the one hand, a unique and potentially invaluable resource. Elsewhere in mathematics education—for example, in the fields of practice and in the institutional arrangements within universities—mathematics and mathematics education exist in different worlds that rarely communicate with each other and most often not well when they do. Yet history teaches us that there is a tradition of healthy interest and engagement of (some) mathematicians in mathematics education, and current experience indicates strongly that mathematicians have vital things to contribute, in multidisciplinary settings, to mathematics education, a potential not always sufficiently appreciated by mathematics educators. On the other hand, mathematicians sometimes lack a sufficient knowledge and/or appreciation of the complex nature of the problems in mathematics education, and they often tend to see issues of

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[4] *An initial aim of the "international journal" (to use its own description)* L'Enseignement Mathématique, *launched in 1899, was "to associate the world of teaching to the 'great movement of scientific solidarity' which was emerging at the end of the 19th century" [1, p. 11]. From the very beginning of the ICMI, L'EM was adopted as its official organ, which is still the case today. The other current channels of communication of the commission are the* ICMI Bulletin, *published twice a year, and the ICMI website,* `http://www.mathunion.org/ICMI/`.

[5] *It is with great sadness that we report the untimely passing of Miguel de Guzmán on April 14, 2004. Information about his life and work can be found at* `http://www.xena.ad/lcf/fev2002/guzman.htm`.

[6] *The successive ICME's, from ICME-2 in 1972 to ICME-9 in 2000, were held respectively in Exeter (UK), Karlsruhe (Germany), Berkeley (USA), Adelaide (Australia), Budapest (Hungary), Québec (Canada), Sevilla (Spain), and Tokyo/Makuhari (Japan). The ICMI has recently accepted the invitation received from Mexico to host the 11th ICME in 2008.*

International Commission on Mathematical Instruction

mathematical integrity and rigor of the curriculum as the beginning and end of the story. (See the *Notices* article by Tony Ralston [6] for an insightful recent commentary on this cross-boundary behavior.) This kind of stance and disposition presents problems when it infects positions of authority and policy setting in mathematics education. In particular, this exposes a latent danger in the inherited governance arrangements of the ICMI, completely under IMU control. Many in the ICMI community argue for greater ICMI autonomy, yet still within the IMU environment.

ICMI vice president Bent Christiansen argued in 1982 that (see [5, p. 260]) the ICMI should *not* decide what are proper or relevant solutions to problems in mathematics education, but should provide a structure under which interaction and exchange of views could be facilitated. It should provide the type of leadership and structure responsive to the needs and interests of the growing mathematics education community and do so under the auspices of the IMU. He also revoiced the frequently expressed need of a permanent secretariat for the ICMI.

Jean-Pierre Kahane, in his 1990 Farewell Message as president of the ICMI, gave the reasons for the ICMI being a commission of the IMU, in terms of

> ...the intimate link between mathematics and its teaching. In no other living science is the part of *mise en forme, transposition didactique,* so important at a research level. In no other science, however, is the distance between the taught and the new so large. In no other science has teaching and learning such social importance. In no other science is there such an old tradition of scientists committed to educational questions ([4, p. 6]; see also [5, p. 262]).

The Structure of the ICMI Today

Structurally the ICMI now exists as a member of the IMU family. After interruptions of activity around the two world wars, the ICMI was reconstituted in 1952, at a time when the international mathematical community was being reorganized, as an official commission of the International Mathematical Union.[7] This still defines the formal position of the ICMI today. Thus, the Terms of Reference of the ICMI are established by the General Assembly of the IMU, which is also responsible for the election of the Executive Committee, the administrative leadership of the ICMI. Furthermore, the vast majority of the funding of the ICMI comes from the IMU. Once these election and budget matters are settled, the ICMI works with a large degree of autonomy.

As is the case for the IMU, members of the ICMI are not individuals, but countries—namely, those countries which are members of the IMU and other countries specifically coopted to the commission. There are currently eighty-one members of the ICMI, sixty-five of which are also members of the IMU. Each member of the ICMI appoints a representative and may create a subcommission for the ICMI. Such a subcommission serves the dual purpose of (a) providing an organized local (national) forum for dealing with issues of mathematics education and for exchange of information, and (b) offering a link between the local and international mathematics education communities. There are currently fourteen such subcommissions.

The ICMI's organizational outreach includes five permanent so-called Affiliated Study Groups, each focusing on a specific field of interest and study in mathematics education consistent with the aims of the commission. The Affiliated Study Groups are neither appointed by the ICMI nor operate on behalf or under the control of the ICMI. They are thus independent of the ICMI for their work, also in terms of finances, but they collaborate with the ICMI on specific activities, such as the ICMI Studies or components of the program of the ICME's. They present reports on their activities to the General Assembly of the ICMI. The current ICMI Affiliated Study Groups, with their year of affiliation, are:

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[7] *Through the IMU, the ICMI thus belongs to the International Council for Science (ICSU). This implies that the ICMI is to abide by ICSU statutes, one of which establishes the principle of nondiscrimination and free circulation of scientists. Lehto's book [5] vividly testifies to the importance of this rule in the life of both the IMU and the ICMI.*

- HPM—*The International Study Group on the Relations between the History and Pedagogy of Mathematics* (1976),
- PME—*The International Group for the Psychology of Mathematics Education* (1976),
- IOWME—*The International Organization of Women and Mathematics Education* (1987),
- WFNMC—*The World Federation of National Mathematics Competitions* (1994), and
- ICTMA—*The International Study Group for Mathematical Modelling and Applications* (2003).

According to its Terms of Reference, the commission is "charged with the conduct of the activities of IMU, bearing on mathematical or scientific education and [takes] the initiative in inaugurating appropriate programs designed to further the sound development of mathematical education at all levels, and to secure public appreciation of its importance." This is clearly reflected in the objectives and activities of the ICMI, which have considerably expanded over the years.

Activities of the ICMI

The ICMI's objective today could be globally described as offering researchers, practitioners, curriculum designers, decision makers, and others interested in mathematical education a forum for promoting reflection, collaboration, exchange and dissemination of ideas, and information on all aspects of the theory and practice of contemporary mathematical education, as seen from an international perspective. How does the commission achieve such aims? We now discuss some of its current major activities and programs.

The ICMI's primary responsibility is to plan for the ICME's, which entails choosing from among host country bids, appointing an international program committee to form the scientific program and select presenters, and overseeing progress of the congress preparations. But the practical and financial organization of an ICME is the independent responsibility of a local (national) organizing committee. This parallels to a large degree what the IMU does for the ICM's. However, the format of an ICME differs interestingly from that of an ICM in that it tends to be much more interactive, involving working groups and study groups that have structured meetings throughout the congress and that may well produce published reports for the congress proceedings.

ICME-10 in Copenhagen in July 2004 (see the next section) will also feature the first awarding of two medals in mathematics education research, recently inaugurated by the ICMI. The Felix Klein Medal for lifetime achievement will be awarded to Guy Brousseau from France. The Hans Freudenthal Medal for a major program of research will be awarded to Celia Hoyles of the UK. Information about these awards and citations of the work of the laureates can be found on the ICMI website, `http://www.mathunion.org/ICMI/`.[8]

A second major ICMI program is the series of ICMI Studies, a most successful set of activities launched in the mid-1980s. Each study focuses on a topic or issue of prominent current interest in mathematics education. Its International Program Committee (appointed by the ICMI) first drafts a "discussion document" that articulates the theme and purpose in great detail. This is widely disseminated to solicit papers from the field. From these submissions, invitations are issued to about eighty participants in an international conference, the results of which are synthesized into a research volume presenting a state-of-the-art expert report on the study theme. This process typically stretches over a period of about three years per study. These studies have acquired a growing importance and influence on the field. Here is a chronological list of past and current studies and their conference sites.

1. *The Influence of Computers and Informatics on Mathematics and Its Teaching* (Strasbourg, France, 1985)
2. *School Mathematics in the 1990s* (Kuwait, 1986)
3. *Mathematics as a Service Subject* (Udine, Italy, 1987)
4. *Mathematics and Cognition* (book prepared by PME, an Affiliated Study Group of ICMI)
5. *The Popularization of Mathematics* (Leeds, UK, 1989)
6. *Assessment in Mathematics Education* (Calonge, Spain, 1991)
7. *Gender and Mathematics Education* (Höör, Sweden, 1993)
8. *What Is Research in Mathematics Education and What Are Its Results?* (College Park, USA, 1994)
9. *Perspectives on the Teaching of Geometry for the 21st Century* (Catania, Italy, 1995)
10. *The Role of the History of Mathematics in the Teaching and Learning of Mathematics* (Luminy, France, 1998)

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[8] *An announcement about the ICMI medals appears in "Mathematics People" in this issue of the* Notices.

11. *The Teaching and Learning of Mathematics at University Level* (Singapore, 1998)
12. *The Future of the Teaching and Learning of Algebra* (Melbourne, Australia, 2001)
13. *Mathematics Education in Different Cultural Traditions: A Comparative Study of East-Asia and the West* (Hong Kong, 2002)
14. *Applications and Modelling in Mathematics Education* (Dortmund, Germany, February 2004)
15. *The Professional Education and Development of Teachers of Mathematics* (Águas de Lindóia, Brazil, May 2005)
16. *Challenging Mathematics in and beyond the Classroom* (Trondheim, Norway, June 2006)
17. *Technology in Mathematics Education* (2006)

The themes of these studies illustrate some of the many domains of mathematics education in which mathematicians, among other expert professionals, have crucial knowledge and expertise to contribute.

The study volumes for the first five studies were published by Cambridge University Press. Since Study 6, the study volumes appear in the New ICMI Study Series (NISS) published by Kluwer Academic Publishers[9] under the general editorship of the president and secretary-general of the ICMI.

Another component of ICMI activities comprises the so-called ICMI Regional Conferences. Despite the international nature of its position and role, the ICMI from time to time lends its name to a variety of regional conferences on mathematics education, primarily in less affluent parts of the world. A number of ICMI Regional Conferences have thus been held over the years. These meetings are supported morally by the ICMI and sometimes with modest financial contributions as well. Recent and forthcoming ICMI Regional Conferences include:

- SEACME-8—*8th South East Asian Conference on Mathematical Education* (Quezon City, Philippines, 1999)
- *All-Russian Conference on Mathematical Education* (Dubna, Russia, 2000)
- ICMI-EARCOME-2—*Second ICMI East Asia Regional Conference on Mathematics Education* (Singapore, 2002)
- XI-IACME—*11th Inter-American Conference on Mathematics Education* (Blumenau, Brazil, 2003)
- EMF 2003—*Espace mathématique francophone 2003* (Tozeur, Tunisia, 2003)
- ICMI-EARCOME-3—*Third ICMI East Asia Regional Conference on Mathematics Education* (Shanghai, China, 2005)
- EMF 2006—*Espace mathématique francophone 2006* (Sherbrooke, Canada, 2006)

In addition to the above activities of a regular nature, the ICMI takes other initiatives on an ad hoc basis. For instance, the ICMI is currently collaborating with UNESCO on an international exhibition on the theme "Why Mathematics?" aimed particularly at young people, their parents, and their teachers. This exhibition will be launched at the 4th European Congress of Mathematics in Stockholm in June 2004. It will then be shown at ICME-10 in Copenhagen and will later travel to various places.

A major aim of the commission is to support the development of mathematics education in less-affluent regions of the world. To this end, the ICMI initiated in the 1990s a Solidarity Program in Mathematics Education based on a twofold approach.

The first component of this program is the ICMI Solidarity Fund, established by the ICMI in 1992 at the suggestion of its president, Miguel de Guzmán. The overall objective of the Solidarity Fund is to increase, in a variety of ways, the commitment and involvement of mathematics educators around the world in order to help the progress of mathematics education in those parts of the world where there is a need for it that justifies international assistance and where the economic and sociopolitical contexts do not permit adequate and autonomous development. This initiative thus aims to foster solidarity in mathematics education between well-defined quarters in developed and less-developed countries. Particular emphasis is placed on projects that enable the activation of a self-sustainable infrastructure within mathematics education in the region, country, or province at issue. Central to this program of international assistance was the establishment of a fund to provide financial support for the approved projects. The Solidarity Fund is based on voluntary donations from individuals and organizations and is kept separate from the ICMI's general funds.

The second component of the ICMI Solidarity Program aims at having a balanced representation from all over the world among the presenters and the general participants in activities such as the ICMI Studies or the ICME's. In support of this goal, the ICMI has implemented, starting with ICME-8 in 1996, a general policy of forming for each ICME an ICME Solidarity Fund established by setting aside 10 percent of the registration fees in order to provide grants to congress delegates from nonaffluent countries. At each of the recent ICME's, some 100 to 150 participants from economically challenged regions of the world have thus been given financial support to facilitate their presence at the congress.

In the same spirit, efforts are made by the organizers of each ICMI Study to find financial resources so as to facilitate the participation in the Study Conference of a substantial delegation from nonaffluent countries.

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[9] `http://www.wkap.nl/prod/s/NISS`.

An Invitation to ICME-10

The 10th International Congress on Mathematical Education, ICME-10, will be held in Copenhagen on the campus of the Technical University of Denmark on July 4-11, 2004. A distinctive flavor of ICME-10 is the fact that it is being hosted, not by a single country, but by the ensemble of the Nordic countries—Denmark, Finland, Iceland, Norway, and Sweden. The congress is expected to gather around 3,500 participants, including mathematicians with an interest in education, researchers in mathematics education, and teachers from all over the world. The International Program Committee, chaired by Mogens Niss[10] (Denmark), proposes a structure combining the best from the ICME tradition with a number of innovative elements and features. The program, whose details can be found on the congress website,[11] includes the following events:

- 8 plenary activities, among which are Plenary Lectures by Hyman Bass (USA), Erno Lehtinen (Finland), Andreas Dress (Germany), and Ferdinando Arzarello (Italy); and reports from so-called survey teams that will present the state of the art with respect to themes such as reasoning, professional development of teachers, testing, or technology, with particular regard to identifying and characterizing important new knowledge, recent developments, new perspectives, and emergent issues;
- 80 regular lectures, covering a wide spectrum of topics, themes, and issues;
- 29 Topic Study Groups, some being organized according to educational levels, others according to content-related issues, and the rest to overarching perspectives and meta-issues;
- 24 Discussion Groups focussing on the examination and discussion of issues that can be dealt with in different ways depending on experiences, values, norms, and judgments;
- a thematic afternoon with 5 parallel miniconferences: *Teachers of mathematics, Mathematics education in society and culture, Mathematics and mathematics education, Technology in mathematics education,* and *Perspectives on research in mathematics education from other disciplines*;
- special sessions of the 5 ICMI Affiliated Study Groups and reports on the 3 most recent ICMI Studies;
- various sets of activities, such as workshops, Sharing Experiences Groups, poster exhibitions, paper presentations, or round-table sessions;
- national presentations from the Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden), Korea, Mexico, Romania, and Russia.

A congress such as ICME-10 provides a unique opportunity to learn about recent developments in mathematics education around the world and to be introduced to innovations and recent research on the teaching and learning of mathematics at all levels, from primary to tertiary education. The scientific program aims to provide food for thought and inspiration for practice to all, from the established mathematics educator to the novice in the field, and to all with an interest in mathematics education. It is structured so as to allow plenty of choice while encouraging exchange and contacts between participants.

In a context where the debate over the state of mathematics education at all levels, from primary school to graduate school, is becoming more intense and vigorous than ever, ICME-10 provides unparalleled access to expert knowledge in the field. ICME-10 can surely play a significant role in facilitating the exchange of ideas and experiments within and between the mathematics and mathematics education communities and contribute to the improvement of mathematics education all around the world.

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[10] `mn@mmf.ruc.dk`.

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Communicating with Congress: An Interview with James H. Turner Jr.

In recent years the mathematical sciences community has greatly stepped up its efforts to advocate increased federal funding for basic scientific research. The AMS Washington Office has been a key player in these efforts. One of the office's main activities is establishing and maintaining relationships with members of Congress and their staffs who have an influence on funding for science.

James H. Turner Jr., chief Democratic counsel for the Committee on Science of the House of Representatives, has become an important figure in the community's relations to Congress. With a bachelor's degree in mathematics and over twenty-five years' experience as a congressional staffer, Turner has a keen appreciation of the need for strong support of the mathematical sciences and a deep understanding of the legislative process.

The House Committee on Science is an authorization committee, which means that it drafts legislation to set spending policies that guide appropriations. The Committee on Science has the responsibility of writing the authorization bills for several federal agencies that fund research, including the National Science Foundation. Turner is a member of the committee staff, which develops legislation for the committee, monitors other bills that have a scientific component, and works on coordinating science funding across the government.

What follows is the edited text of an interview with Turner in which he discusses the outlook for research funding and how the mathematical sciences community can build effective relations with Congress. The interview was conducted by *Notices* senior writer Allyn Jackson during the Joint Mathematics Meetings in Phoenix in January 2004. Assistance during the interview and in preparing the final text was provided by Samuel M. Rankin III, director of the AMS Washington Office.

—A. J.

Notices: *What is your prognostication for funding for science in the next few years?*

Turner: I think it is very much an open question. Some of the people who were the longtime advocates of science funding are no longer in Congress. There is a new group that has stepped up, and whether they are going to be as effective as their predecessors remains to be seen. Also, it is not entirely clear what the administration's positions are going to be on various issues after the election. President Bush seems to be committed not to roll back any of the tax cuts, so the amount of money that the government will have will not increase and will probably decrease. A compounding factor is the growth of the federal deficit. I don't think there is anyone who believes that the size of the deficit can continue at the levels it is in the indefinite future. These factors put pressure on science funding. That's the bad news. The good news is, first, that hopefully the economy will improve and, second, that the science community is organized much more than it was as recently as ten years ago. The mathematics community is a very integral part of and one of the organizers of the new regime.

Notices: *So you have seen a real change in the capability of the scientific community to affect science funding?*

Turner: Yes, very much so. There are several changes that took place. In 1995, when the Republicans came to power, one of the things that happened was that the Office of Technology Assessment [OTA], which was one of the main sources of advice to Congress, was abolished. Fortunately, the scientific community, including the American Mathematical Society, has stepped in to fill that void. Under the leadership of Dr. Rankin [Samuel M. Rankin III, director of the AMS Washington Office], there have been one or two sessions every year where distinguished mathematicians make presentations to as many as one hundred members of Congress and staff about how mathematics relates to important issues like the biological sciences or cryptography or image recognition. OTA did very little related to mathematics. Now that the American Mathematical Society has stepped in, I think there is more of an opportunity for the Congress to understand the contributions that mathematics makes. A second area is events like Congressional Visits Day, which was started about the same time. The American Mathematical Society has been one of the participating societies. On Congressional Visits Day scientists and mathematicians come to Washington to meet with members of Congress. So there are some positive effects as well as pressures we are under.

James H. Turner

***Notices:** The outlook for mathematics funding at the NSF became much rosier when Philippe Tondeur became the director of the Division of Mathematical Sciences there.*

Turner: There were certain things that happened. During his tenure there was specifically a mathematical sciences initiative. The question of whether another initiative can follow on to that —we are about ready to enter into the final year of that initiative—is problematic, because there are a lot of other disciplines that have needs as well.

So it is important for mathematicians to participate in the process at various levels. It is important for more mathematicians to get to know their home district congressmen—and senators, if possible. The purpose is not just to go in and ask for more money, but to make sure that congressmen—who make many of their decisions based on how they affect the local area—know what is happening in their universities and how mathematics and science play a role in economic development; in having a high-quality workforce; and in preparing people in the social, physical, and biological sciences, which are becoming much more math-intensive. The world is becoming much more quantitative, and that knowledge doesn't happen by accident; it comes by hard work and by having opportunities available.

***Notices:** Do people from other sciences go to see their congressmen more than mathematicians do?*

Turner: If one considers how big the mathematical societies are as a percentage of the total scientists and engineers, mathematicians probably are at or above average. But the mathematical societies are a lot smaller than, for example, the American Chemical Society or the Institute of Electrical and Electronics Engineers. The fact that those societies are perhaps ten times as large means that there are a lot more things they are capable of doing. This also means that it's important for the mathematical societies—as they have done—to be partners with other scientific and engineering societies. Part of the message is the importance of mathematics, and part of the message is the importance of mathematics, science, and technology in general, because if the overall science funding goes up, funding for mathematics will probably go up.

***Notices:** It's hard for pure mathematicians to explain their work to their congressmen. How can they express to people in Congress that what they do in pure mathematics is relevant and useful?*

Turner: There are any number of examples of mathematical discoveries that have been made in the past that are now becoming relevant. If you look at telecommunications, the Internet as an example, there are a number of things that were discovered through basic research that have been put to use. The pure mathematicians you mentioned can call on the parent societies for such examples. Also, they do not necessarily have to talk to the member about what they are doing, but about what mathematics is doing in general. It's not necessary to sell just one's own research.

If I am at a university like Yale University and I go in to see my congressman, the congressman is not going to see me as an individual. I am going to be seen as a member of the mathematics department at Yale and also as a person who is, in this example, employed at the largest employer in that congressional district. So what I am representing is a research university where mathematics, the sciences, and engineering may be the hope of the future of that congressman's area. It's the source of talented workers; it's the source of ideas that are spun off. Most of the congressmen thank their lucky stars that those institutions are in their districts. So part of the sale has already been made by whom you are representing—especially if you visit the member when he or she is back home.

It may not be a customary position to be in, but to a certain extent what you are being is a salesman. Anybody who is being a salesman has to know what his or her customer needs and cares about and to adapt arguments accordingly. It is very rare for a congressman to know a lot of mathematics. Most of them are lawyers or English majors or history majors. But it is equally rare for a congressman not to be very smart, and because of the nature of their jobs, they have been exposed to a wide variety of ideas and opinions. So they have the ability, even if they are not analytical, to put things in context in a way that a lot of people are not able to do. The congressional staff, who would in most cases be younger and less experienced than their congressman, operate in the same spirit and are trained to think very broadly and understand a large range of issues.

It's very important for scientists who want to help in this way to work closely with the Washington offices of the mathematics societies, which can provide resources and advice. You are certainly not alone when you do it. You are part of a very big team that is trying to educate a finite number of people on the importance of mathematics, science, and technology. You'll be successful, as you are in any team effort, if you work as a team and build on the strengths of your colleagues.

***Notices:** What about the argument that mathematics is valuable just intrinsically as an intellectual discipline? Does that argument resonate with congressmen at all, or do you always have to say, "mathematics is useful in technology"?*

Turner: One thing that is important to remember is that what mathematicians think about on a daily basis and what congressmen think about on a daily basis is usually very different. If your daily life is made up of ten or more meetings with lots of diverse groups and you are voting on different kinds of legislation every day that Congress is in session, then you are pulled in many different directions and are not thinking in-depth on a particular issue in the way a mathematician is. So that means that things that are intuitive and obvious to a mathematician are going to be things congressmen never think about. You may well be the first mathematician who engages the congressman in a conversation—usually they are talking to businessmen in their district or to the Kiwanis Club. They are going to be interested in how mathematics affects their lives. But you are only going to get twenty or thirty minutes to make your presentation, so you have to be very organized. Sometimes you hit the jackpot and you spark an idea that really leads to broader thinking. That won't happen every time; maybe it won't happen often.

One congressman I worked for said that the two most important things to remember when you are dealing with Congress is, first, that Congress is an oral society or, if you will, a debating society, and, second, a good story rather than a good fact is the currency of the realm. So if I were going to make a presentation to a member, I would not spend my time explaining my work. I would think about stories about how mathematics in my district made a difference or, if I am trying to sell something that is a broader bill, examples of how mathematics has made a real difference economically or in scientific discovery. A good example currently is the Mars lander. I'd be very surprised if more than a handful of members of Congress really realize to what extent that is not only an engineering enterprise but also a very complex mathematical enterprise. There is always something current in the news where mathematics has made a contribution.

***Notices:** How important do you think the issue of homeland security and the antiterrorist effort is in influencing funding in mathematics?*

Turner: My personal opinion is that it's going to be a fair amount of work, but that is one of the real targets of opportunity. The Department of Homeland Security was forged from many disparate agencies, some of which had research operations. A variety of scientific endeavors came into the department, but they are not an integral whole. The legislation creating the Department of Homeland Security created an undersecretary focused mainly on research and development. So there is at a high level a very logical place for mathematics to enter into the Department of Homeland Security. The other thing that is happening, which is unique among agencies at this time, is that that department is in a formative stage and growing rapidly. Part of the funding will be spent through an analog to DARPA [Defense Advanced Research Projects Agency], which has funded some mathematicians in the past. Some of the research will be funded, I am sure, with individual investigator grants. I would not hold my breath for there to be a lot of basic research there. But when you think about the kinds of problems that the Department of Homeland Security has to wrestle with, many of them have a mathematical basis. So if I were king of the American Mathematical Society—I realize you don't have that position yet!—this is one of the things I would really be concentrating on.

***Notices:** What about the huge advances in biomedical science? Do you think there is potential for the mathematics budget to rise along with increases in funding for biomedical science?*

Turner: That is a little tougher situation. I think the answer is yes, but yes over time. I don't think mathematics people have gotten anywhere near the credit they should have for these advancements in biology. But biologists are becoming more and more dependent on mathematical knowledge. I think it is a natural progression for mathematicians to be more frequently on teams that are applying for NIH [National Institutes of Health] grants. The idea of having a source within NIH where individual investigators in mathematics can apply is really a tougher sell. It will take time, considering that there are so many interests already at the table and that the budgets there are not growing as fast as before. Mathematicians will benefit in direct proportion to the extent that biologists realize that mathematicians have solutions to their problems.

***Notices:** Do you think that mathematicians who are visiting congressmen with the aim of increasing research funding should bring up math education?*

Turner: Oh, absolutely, because math education is one of the easiest issues for members to understand. It can be an ice breaker; it can be a good source of anecdotes. The only caveat is that if you have a limited amount of time, you can only break so much ice, and you have to get down to what the real purpose of your visit is.

I think mathematics and science education also is a wonderful way to build a relationship with a member in your home area. If your area has an exceptional program, on the day it's being shown off, why not invite your congressman to introduce the math teachers or come meet some math students in a competition? It's an opportunity for the congressman to get his picture in the paper, and it's an opportunity for you to get in the press—so it's a win-win situation.

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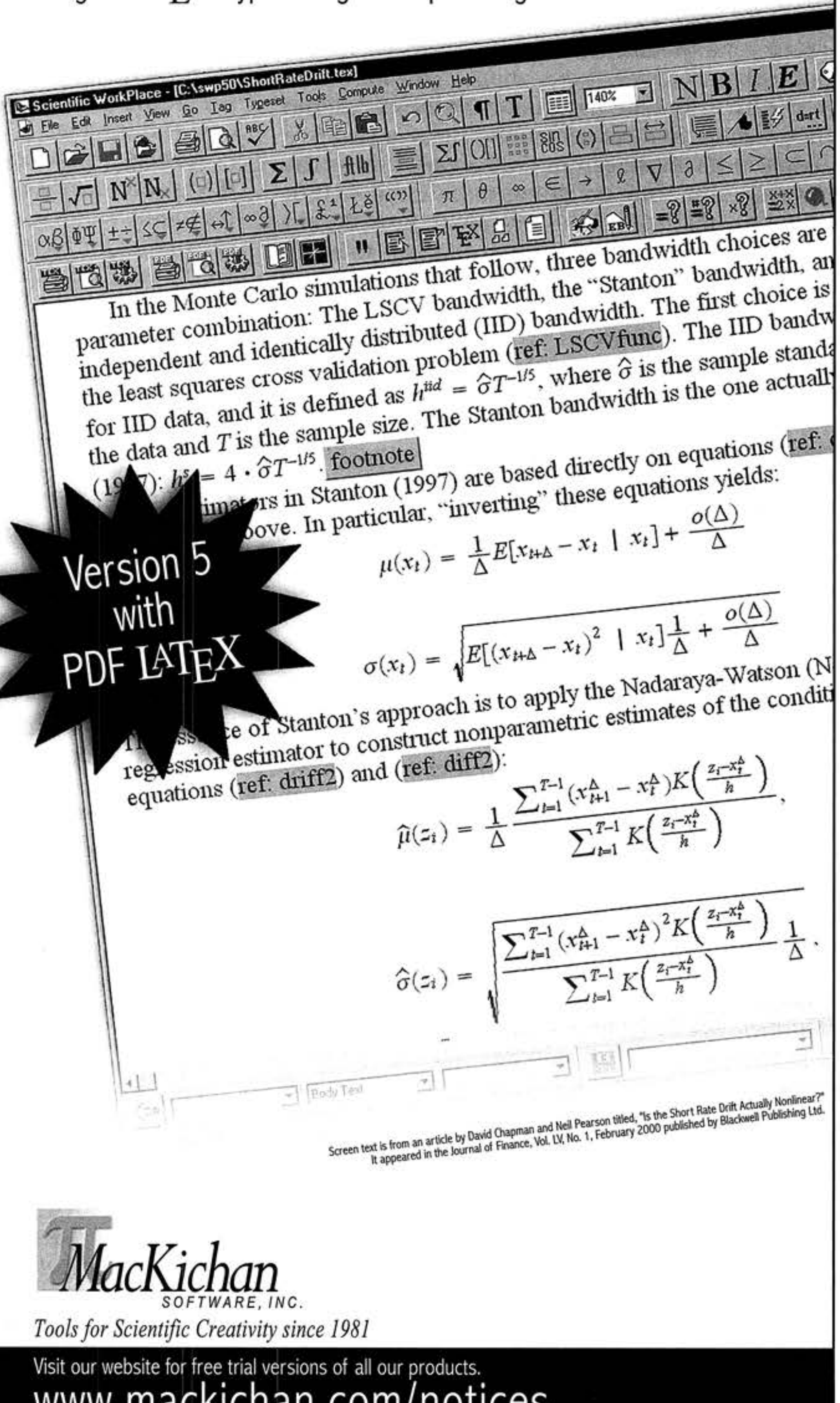

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In the Monte Carlo simulations that follow, three bandwidth choices are
parameter combination: The LSCV bandwidth, the "Stanton" bandwidth, an
independent and identically distributed (IID) bandwidth. The first choice is
the least squares cross validation problem (ref: LSCVfunc). The IID bandw
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the data and T is the sample size. The Stanton bandwidth is the one actuall
(19 7): $h^s = 4 \cdot \hat{\sigma}T^{-1/5}$. footnote
imat rs in Stanton (1997) are based directly on equations (ref:
ove. In particular, "inverting" these equations yields:

$$\mu(x_t) = \frac{1}{\Delta}E[x_{t+\Delta} - x_t \mid x_t] + \frac{o(\Delta)}{\Delta}$$

$$\sigma(x_t) = \sqrt{E[(x_{t+\Delta} - x_t)^2 \mid x_t]\frac{1}{\Delta} + \frac{o(\Delta)}{\Delta}}$$

e of Stanton's approach is to apply the Nadaraya-Watson (N
regression estimator to construct nonparametric estimates of the conditi
equations (ref: driff2) and (ref: diff2):

$$\hat{\mu}(z_i) = \frac{1}{\Delta}\frac{\sum_{t=1}^{T-1}(x_{t+1}^{\Delta} - x_t^{\Delta})K\left(\frac{z_i - x_t^{\Delta}}{h}\right)}{\sum_{t=1}^{T-1}K\left(\frac{z_i - x_t^{\Delta}}{h}\right)},$$

$$\hat{\sigma}(z_i) = \sqrt{\frac{\sum_{t=1}^{T-1}(x_{t+1}^{\Delta} - x_t^{\Delta})^2 K\left(\frac{z_i - x_t^{\Delta}}{h}\right)}{\sum_{t=1}^{T-1}K\left(\frac{z_i - x_t^{\Delta}}{h}\right)}\frac{1}{\Delta}},$$

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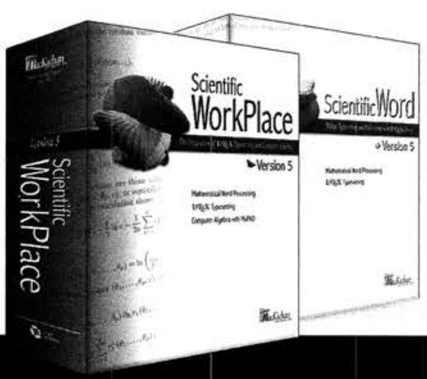

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Atiyah and Singer Receive 2004 Abel Prize

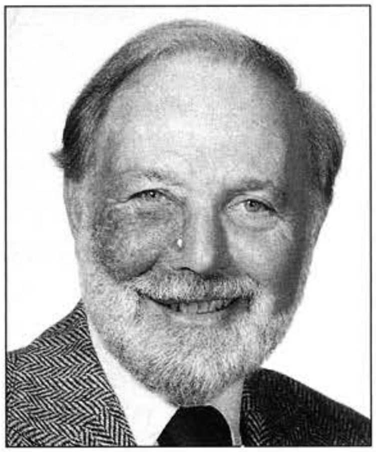
The Norwegian Academy of Science and Letters has decided to award the Abel Prize for 2004 jointly to Sir Michael Francis Atiyah of the University of Edinburgh and Isadore M. Singer of the Massachusetts Institute of Technology. They are receiving the prize "for their discovery and proof of the index theorem, bringing together topology, geometry and analysis, and their outstanding role in building new bridges between mathematics and theoretical physics."

The Atiyah-Singer index theorem is one of the great landmarks of twentieth-century mathematics, influencing profoundly many of the most important later developments in topology, differential geometry, and quantum field theory. Its authors, both jointly and individually, have been instrumental in repairing a rift between the worlds of pure mathematics and theoretical particle physics, initiating a cross-fertilization that has been one of the most exciting developments of the last few decades.

Michael Francis Atiyah and Isadore M. Singer are among the most influential mathematicians of the last century and are still working. With the index theorem they changed the landscape of mathematics. Over a period of twenty years they worked together on the index theorem and its ramifications.

Atiyah and Singer came originally from different fields of mathematics—Atiyah from algebraic geometry and topology, Singer from analysis. Their main contributions in their respective areas are also highly recognized. Atiyah's early work on meromorphic forms on algebraic varieties and his important 1961 paper on Thom complexes are such examples. His pioneering work with Friedrich Hirzebruch on the development of the topological analogue of Grothendieck's K-theory had numerous applications to classical problems of topology and turned out later to be deeply connected with the index theorem.

Sir Michael Francis Atiyah



Isadore M. Singer

Singer initiated the subject of triangular operator algebras (jointly with Richard V. Kadison). His name is also associated with the Ambrose-Singer holonomy theorem and the Ray-Singer torsion invariant. Singer, together with Henry P. McKean, pointed out the deep geometrical information hidden in heat kernels, a discovery that had great impact.

Biographical Sketch: Michael Atiyah

Michael Francis Atiyah was born in 1929 in London. He got his B.A. and his doctorate from Trinity College, Cambridge. The greatest part of his academic career was spent in Cambridge and Oxford. He has held many prominent positions, among them the highly prestigious Savilian Chair of Geometry at Oxford and that of Master of Trinity College, Cambridge. Atiyah has also been professor of mathematics at the Institute for Advanced Study in Princeton.

Atiyah rejuvenated British mathematics during his years at Oxford and Cambridge. He was also the driving force behind the creation of the Isaac Newton Institute for Mathematical Sciences in Cambridge and became its first director. Atiyah is now retired and an honorary professor at the University of Edinburgh.

Atiyah has received many honors during his career, including the Fields Medal (1966). He was elected a Fellow of the Royal Society, London, in 1962 at the age of thirty-two. He was awarded the Royal Medal of the Society in 1968 and its Copley Medal in 1988. Atiyah was president of the Royal Society from 1990 to 1995. He has served as president of the London Mathematical Society (1974–76). He has also played an important role in the shaping of today's European Mathematical Society.

Atiyah was responsible for the founding of the Inter-Academy Panel that brought together many of the world's academies of science. Atiyah also instigated the formation of the Association of European Academies (ALLEA). He has been president of Pugwash Conferences on Science and World Affairs.

Among the prizes he has received are the Feltrinelli Prize from the Accademia Nazionale dei Lincei (1981) and the King Faisal International Prize for Science (1987). Atiyah was knighted in 1983 and made a member of the Order of Merit in 1992.

Biographical Sketch: I. M. Singer

Isadore M. Singer was born in 1924 in Detroit and received his undergraduate degree from the University of Michigan in 1944. After obtaining his Ph.D. from the University of Chicago in 1950, he joined the faculty at the Massachusetts Institute of Technology. Singer has spent most of his professional life at MIT, where he is currently an Institute Professor.

Singer is a member of the American Academy of Arts and Sciences, the American Philosophical Society, and the National Academy of Sciences (NAS). He served on the Council of the NAS, the Governing Board of the National Research Council, and the White House Science Council. Singer was vice president of the AMS, 1970–72.

In 1992 Singer received the AMS Award for Distinguished Public Service. The citation recognized his "outstanding contribution to his profession, to science more broadly and to the public good."

Among the other awards he has received are the Bôcher Prize (1969) and the Steele Prize for Lifetime Achievement (2000), both from the AMS, the Eugene Wigner Medal (1988), and the National Medal of Science (1983).

In his response upon receiving the Steele Prize (*Notices*, April 2000), Singer stated: "For me the classroom is an important counterpart to research. I enjoy teaching undergraduates at all levels, and I have a host of graduate students, many of whom have ended up teaching me more than I have taught them." Singer has also written influential textbooks that have inspired generations of mathematicians.

—From a news release of the Norwegian Academy of Science and Letters

About the Abel Prize

The Abel Prize is presented by the Norwegian Academy of Science and Letters in recognition of outstanding scientific work in the field of mathematics. The prize amount is 6 million Norwegian kroner (about US$625,000). On the committee choosing the recipients of the 2004 Abel Prize were David Mumford, Jacob Palis, Erling Størmer (chair), Gilbert Strang, and Don Zagier. The Abel Prize was awarded for the first time in 2003 to Jean-Pierre Serre.

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Has Math Funding Hit the Deficit Wall?: The NSF Fiscal Year 2005 Budget Request

This article is the 32nd in a series of annual reports outlining the president's request to Congress for the budget of the National Science Foundation. Last year's report appeared in the June/July 2003 issue of the *Notices*, pages 687–9.

The process of building a budget for the federal government for fiscal year 2005 began in February this year, when the Bush administration sent its budget request to Congress. The request includes the administration's outline for what it believes the government should spend on basic research. Hemmed in by a ballooning deficit and mounting war costs, the fiscal 2005 budget is shaping up to be quite stringent as far as funding for basic research is concerned. In particular, the budget for the National Science Foundation (NSF) would rise just 3 percent under the terms of the request.

This bleak outlook for research funding was one of the main issues discussed at the AMS Committee on Science Policy Forum, held April 1–3, 2004, in Washington, DC. The annual CSP Forum is a venue for presentations by governmental representatives about the status of research funding. In recent years, mathematics department chairs from around the country have been invited to take part in the forum, and this year seventeen attended. Also present were several members of the AMS Council, in town for their meeting being held the same weekend. Altogether, about fifty people came to the forum. The variety of viewpoints and the lively discussions made for a meeting that was, in the words of AMS vice president Vaughan Jones of the University of California at Berkeley, "fascinating."

Pressures on the Budget

The administration's request is the first step in the process of appropriating a budget for the federal government. Congress will spend the summer debating and reworking the budget, with the aim of enacting appropriations bills by the start of fiscal year 2005 on October 1, 2004. Often there are delays in passing the bills. Indeed, the fiscal 2004 appropriations were passed almost four months late, and at the time of the CSP Forum the NSF's Division of Mathematical Sciences (DMS) did not yet have official budget numbers for 2004. Predictions of delays for fiscal 2005 were already being made at the CSP Forum. The November presidential election increases the likelihood of delays.

Basic research does not fare well in the 2005 request. One of the speakers at the CSP Forum was Michael Stephens, who is on the staff of the House Appropriations Subcommittee on Veterans Affairs, Housing and Urban Development, and Independent Agencies; this is the subcommittee that has the final say on the budget of the National Science Foundation. Stephens summed up the overall mood: "Reality check: It's very bleak." To understand some of the reasons for the pessimism, one need only look at recent news headlines about mounting bills for the war in Iraq and the fight against terrorism. Perhaps even more worrisome is the escalating federal deficit. Stephens said that in his twenty-eight years working for Congress he has seen only two other periods where deficit problems loomed as large. One was 1981–82, the era of Gramm-Rudman austerity, when the deficit was around $50 billion and many government programs were cut by as much as 20 percent. The other period was 1995–96, when Republicans who had recently taken control of the House of Representatives enacted deep cuts to address a $290 billion deficit. Now the deficit stands at $521 billion. The psychology of thinking about governmental spending, Stephens noted, is dominated by this figure.

"It is a hugely constrained system for funding," he said.

Another factor ratcheting up the pressure on the research budget is the increase in earmarking, also known as "pork barrel" funding. An earmark is an appropriation for a specific project awarded to a specific institution without any competitive process. Many colleges and universities receive such earmarked funding by lobbying members of Congress. According to the *Chronicle of Higher Education*, which tracks pork barrel funding directed to academia, Congress awarded a total of $2 billion in pork barrel grants, a 10 percent increase over the previous year. Since 1996, funding devoted to such earmarks has increased by a factor of six. The rise in earmarking reflects the squeeze on federal funds: As the budget tightens, more institutions are willing to use lobbying and political muscle to get money.

In his presentation before the CSP, James H. Turner Jr. called the increase in earmarking "an absolutely unprecedented change and a new way of doing business." Turner is the Chief Democratic Counsel for the Committee on Science of the House of Representatives and has worked as a congressional staffer for more than twenty-five years.[1] "We have to watch out for the impact on peer review" that may come from the increase in earmarking, he said. He also pointed out that earmarked grants would not exist if colleges and universities did not accept them. While "there has been an explosion of earmarking," Stephens said, the NSF has been largely free of it. Stephens made a distinction between congressional additions to the NSF budget, which are sometimes referred to as earmarks, and true earmarks, which completely circumvent peer review. For example, Congress

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[1] *An interview with Turner appears in this issue of the* Notices.

Table 1: National Science Foundation (Millions of Dollars)

	2001 Actual	Change	2002 Actual	Change	2003 Actual	Change	2004 Plan	Change	2005 Request
(1) Mathematical Sciences Research Support	$ 121.4	24.8%	$ 151.5	18.0%	$ 178.8	12.1%	$ 200.4	0.9%	$ 202.2
(2) Other Research Support (Note a)	3370.2	6.2%	3579.8	13.3%	4054.7	3.7%	4205.9	6.1%	4463.3
(3) Education and Human Resources (Note b)	795.4	8.9%	866.1	7.9%	934.9	0.4%	939.0	-17.9%	771.4
(4) Salaries and Expenses (Note c)	172.9	2.1%	176.6	13.8%	201.0	15.7%	232.5	32.5%	308.1
(5) Totals	$4459.9	7.0%	$4774.1	12.5%	$5369.3	3.9%	$5577.8	3.0%	$5745.0
(6) (1) as a % of the sum of (1) and (2)	3.48%		4.06%		4.22%		4.55%		4.33%
(7) (1) as a % of (5)	2.72%		3.17%		3.33%		3.59%		3.52%

Tables prepared by Notices *staff.*

Note a: Support for research and related activities in areas other than the mathematical sciences. Includes scientific research facilities and instrumentation. **Note b:** Support for education in all fields, including the mathematical sciences. **Note c:** Administrative expenses of operating the NSF, including the National Science Board and the Office of the Inspector General.

Table 2: Directorate for Mathematical and Physical Sciences (Millions of Dollars)

	2001		2002		2003		2004		2005	
	Actual	% of Total	Actual	% of Total	Actual	% of Total	Plan	% of Total	Request	% of Total
(1) Mathematical Sciences	$121.4	14.2%	$151.5	16.5%	$178.8	17.2%	$ 200.4	18.4%	$ 202.2	18.1%
(2) Astronomical Sciences	148.7	17.4%	166.0	18.0%	187.1	18.0%	196.5	18.0%	204.4	18.3%
(3) Physics	187.5	22.0%	195.9	21.3%	224.5	21.6%	$ 227.7	20.9%	235.8	21.1%
(4) Chemistry	154.3	18.1%	162.8	17.7%	181.6	17.4%	185.2	17.0%	188.9	16.9%
(5) Materials Research	209.7	24.5%	219.4	23.8%	241.4	23.2%	250.9	23.0%	253.2	22.7%
(6) Office of Multidisciplinary Activities	32.4	3.8%	24.8	2.7%	27.3	2.6%	30.8	2.8%	31.0	2.8%
(7) Totals	$854.1	100.0%	$920.4	100.0%	$1040.7	100.0%	$1091.5	100.0%	$1115.5	100.0

may direct the NSF to launch a program of grants to two-year colleges, but the grants would still be awarded through a peer-review process.

According to an analysis by the American Association for the Advancement of Science (AAAS), total federal research and development funding would rise 4.3 percent under the terms of the budget request. That increase is concentrated in weapons development, homeland security, and the National Institutes of Health (NIH). Cuts are proposed in basic research at the Department of Defense, the Department of Energy, the U.S. Geological Survey, and other agencies. In this context, the 3.0 percent increase for the NSF looks like a relative bright spot. Still, a question that must have been on the minds of many CSP members was, Whatever happened to the plan to double the NSF budget over five years—a plan authorized by Congress in late 2002? Carrying out this plan would have meant double-digit increases for the NSF until 2007.

AMS president David Eisenbud posed this question to David Trinkle, a staff specialist in the Office of Management and Budget who made a presentation before the CSP. Trinkle's reply may be summed up in the familiar Washington refrain: an authorization is not an appropriation. Authorizations express support for spending plans; appropriations provide the dollars. The bill authorizing the doubling had widespread support. "The president signed it," Trinkle said. "We took it as a potential plan forward. Meanwhile, the economy tanked and wars came up. There is still a lot of good will toward the NSF, but it's hard to see how the doubling can happen." A similar drive to double the budget of the NIH was successful; its budget went from $14 billion in 1998 to a requested level of $29 billion this year. The NIH benefited from budget surpluses following 1998. For the NSF, the timing was less fortunate. As Stephens put it, "The NSF advocacy hit its stride when the money dried up."

Mathematical Sciences Priority Area

The NSF has committed itself to emphasizing five "priority areas", one of them being the mathematical sciences. The other four are Biocomplexity in the Environment, Human and Social Dynamics, Nanoscale Science and Engineering, and Workforce for the 21st Century. Except for Nanoscale Science and Engineering, which would get a substantial increase of 20.3 percent for a total of $305.1 million, funding for the other priority areas would be flat under the terms of the budget request. In particular, the mathematical sciences priority area would get essentially no increase. Stephens said that, in his personal view, it makes little sense to declare all five areas to be priority areas and then give one a large increase and leave the others flat. Nevertheless, he observed, "This is an indication of the difficult choices people are making."

The mathematical sciences priority area is now in its second year. One of its biggest proponents was former NSF director Rita Colwell, who abruptly left the Foundation in February; her term was supposed to have ended in August. In the fiscal 2005 request, its funding would rise by just $20,000, from $89.09 million to $89.11 million; the increase would be for joint projects with the Office of Polar Programs. While this increase may seem small, it should be noted that, when the priority area was established in 2003, the NSF projected it would spend only $86 million on it by 2005. Of the $89.11 million for the priority area, $67.39 million would be in the DMS budget, the same amount as in fiscal 2004. The remaining $21.72 million would be spread around the foundation to support interdisciplinary projects involving the mathematical sciences. The DMS has clearly benefited from the priority area: its budget has grown 65 percent since 2001, when the division first started receiving big increases in anticipation of the establishment of the priority area. Under the fiscal 2005 request, the DMS budget would rise from an estimated $200.41 million in fiscal 2004 to $202.25 million, an increase of 0.9 percent.

Still, there appeared to be no disagreement with the general message that the mathematical sciences are underfunded compared to other areas.

In a presentation before the CSP, acting executive officer Deborah Lockhart described some of the things the division has done with the new money gained with its recent increases. The VIGRE program (Vertical Integration of Research and Education) has been a major emphasis, and last year the DMS added two companion programs, Research Training Grants (RTGs) and Mentoring through Critical Transition Points (MCTP). The RTGs are similar to VIGRE grants in that they are "vertically integrated", involving undergraduates, graduate students, postdocs, and faculty. But the RTGs involve smaller groups and have a more focused research agenda than do the VIGRE projects. In addition, they do not require activities that cut across an entire mathematics department, as VIGRE projects generally do. The RTGs differ from the similarly named Focus Research Groups (FRGs), which need not involve vertically integrated activities. While FRGs do often contain substantial support for graduate students and postdocs, the focus of an FRG proposal must be research focused on a well identified problem. RTGs, by contrast, are intended to support workforce activities within a strong research group, and the substantial majority of the funds must be in student and postdoc stipends. The MCTP program supports projects to facilitate transitions an individual must make along the path to becoming a mathematician. These transitions might be from a bachelor's degree program to a doctoral program, or even from high school to college. The first round of RTGs and MCTP grants will be announced this summer; awards will run about $500,000 per year for one to five years.

VIGRE, the RTGs, and the MCTP program together come under the rubric of Enhancing the Mathematical Sciences Workforce for the 21st Century (EMSW21). The 2005 budget request calls for a $2.0 million increase for EMSW21, for a total of $27.78 million, through reorientation of $1.50 million from the Faculty Early Career Development (CAREER) program and $500,000 from postdoctoral fellowship activities. Another DMS program slated for an increase under the terms of the request is the mathematical sciences research institutes, of which there are now five. Total funding for the institutes would climb $1.5 million, to $16.6 million, "to address the growing interface with other disciplines," the request states.

DMS director William Rundell was traveling abroad and could not attend the CSP Forum. In an interview, he noted that the contraints on the budget mean that new initiatives are unikely to be launched in fiscal year 2005. "We have to look at the best things we are doing and do them at full power," he remarked. "Less interesting things may be phased out. But we will protect the disciplinary core at all costs. We are not going to reduce the single-investigator program... The pieces that are important to us will not be cut." In particular, he said that although there will be belt-tightening in 2005, he does not foresee a reduction in the number of investigators supported by the DMS.

Upping Grant Size

Lockhart also said that the DMS has in recent years devoted funds to increasing grant size and duration. In doing so, the DMS is abiding by an NSF-wide policy set some years ago by the National Science Board, the NSF's governing body. Indeed, the fiscal 2005 request explicitly states that one of the goals for the mathematical sciences priority area is to "[b]ring support for researchers in the mathematical sciences to a level competitive with other sciences and recognize mathematicians and statisticians as full partners in research, by increasing award size and duration." Within the DMS, the increase in award size has primarily gone toward adding more graduate students and postdocs to the top-rated awards.

The issue of bringing support for researchers in the mathematical sciences to a level comparable with those in other areas was one of the topics of a discussion during the CSP Forum. But the way the issue was framed in the CSP was in terms of numbers of researchers supported, not size and duration of awards. During the discussion, CSP chair Jane Hawkins of the University of North Carolina, Chapel Hill, displayed a graph of NSF data entitled "Percentage of Full-Time Academics Receiving Federal Research Support". According to this graph, for example, 50.4 percent of researchers

Table 3: Compilation of NSF Budget, 1999–2005 (Millions of Dollars)

	1999 Actual	2000 Actual	2001 Actual	2002 Actual	2003 Actual	2004 Plan	2005 Request	1999–2003 Change	1999–2005 Change
(1) **Mathematical Sciences Research Support**	$ 100.7	$ 106.0	$ 121.4	$ 151.5	$ 178.8	$ 200.4	$ 202.2	77.6%	100.8%
Constant Dollars	*60.4*	*61.6*	*68.5*	*84.2*	*97.2*			*60.9%*	
(2) **Other Research Support (Note a)**	2777.6	2978.9	3370.2	3579.8	4054.7	4205.9	4463.3	46.0%	60.7%
Constant Dollars	*1667.2*	*1729.9*	*1903.0*	*1989.9*	*2203.6*			*32.2%*	
(3) **Education and Human Resources (Note b)**	662.5	683.6	795.4	866.1	934.9	939.0	771.4	41.1%	16.4%
Constant Dollars	*397.7*	*397.0*	*449.1*	*481.4*	*508.1*			*27.8%*	
(4) **Salaries and Expenses (Note c)**	149.5	154.9	172.9	176.6	201.0	232.5	308.1	34.4%	106.1%
Constant Dollars	*89.7*	*89.9*	*97.6*	*98.2*	*109.2*			*21.7%*	
(5) **Totals**	$3690.3	$3923.4	$4459.9	$4774.1	$5369.3	$5577.8	$5745.0	45.5%	55.7%
Constant Dollars	*2215.1*	*2278.4*	*2518.3*	*2653.8*	*2918.1*			*31.7%*	

Current dollars are converted to constant dollars using the Consumer Price Index (based on prices during 1982–1984).

For Notes a, b, and c, see Table 1.

in the physical sciences and 52.9 percent in computer science receive federal support. Mathematics, with 28.3 percent, had the lowest proportion of the six areas on the graph. Some were skeptical about the numbers, asking "What is the denominator?" in the percentage calculations. Still, there appeared to be no disagreement with the general message that the mathematical sciences are underfunded compared to other areas.

However, there did not seem to be a consensus that grants in the mathematical sciences need to be bigger. AMS Council member John McCarthy of Washington University in St. Louis said that, in the short term, the mathematical sciences are being hurt by the drive to increase award size. He said it seemed that the DMS funded only about a third of proposals. When he participated in a DMS proposal-reviewing panel, there was a large group of people doing good research who were turned down. "Mathematics is different from lab sciences", he said after the CSP meeting. "We don't need large grants to buy equipment. At current funding levels, it would be better if we had more, smaller grants." Jonathan Wahl of the University of North Carolina, Chapel Hill, said that mathematicians just starting their careers might need full summer support and that senior mathematicians, with higher salaries, can frequently make do with less, especially if the outcome is that many more people receive funds for travel and other activities that facilitate research. With NSF grants, he noted, mathematicians either get a large amount of funds, or they get nothing. He suggested that the awarding of DMS grants should reflect less this kind of "all-or-nothing" model.

Samuel M. Rankin III, director of the AMS Washington office, suggested that it would be a losing strategy for mathematicians to volunteer to take smaller grants. Indeed, past efforts to limit the size of DMS grants in order to fund more mathematicians have usually failed. One reason is that arguments to simply spread the money more thinly and more widely have little resonance within the upper echelons of the NSF. In addition, the success rate for proposals made to the DMS is comparatively high, averaging 37 percent over the past ten years. Without more "proposal pressure" in the mathematical sciences, arguments to increase the number of grants given by the DMS are unlikely to be persuasive.

One controversial point in the 2005 request that kept coming up during the CSP Forum but that is not directly related to mathematics research, is the fate of the Math and Science Partnerships (MSP) program at the NSF, which was begun with a budget of $160 million in 2002. This program aims to establish partnerships between school districts and institutions of higher education to strengthen K–12 mathematics and science education. The fiscal 2005 budget request proposes phasing out MSP and shifting the funds to the Department of Education (DoEd) to start a program focused on high school mathematics. One reason for the controversy is that the existing MSP grants were awarded through the NSF's competitive process of peer review. The DoEd, by contrast, traditionally awards funds to states on a formula basis. The intention is that the DoEd program would be competitive, but, as Rankin pointed out, Congress would have to pass a new law for that to happen. The proposed shift of the MSP funds to DoEd has been criticized by many, including influential members of Congress. The National Science Board has also publicly voiced its opposition.

From the start the administration's 2005 budget request for the NSF was seen as inadequate by strong supporters of science in the House and the Senate. By the time of the CSP Forum, many of these supporters had made their views known to the appropriations committees, urging that increases for the NSF be made a high priority in spite of the severe budget constraints. "We have come a long, long way in the past five to ten years in the visibility of science and technology on Capitol Hill," Turner told the CSP. The scientific community, including the AMS, he said, has pulled together to advocate increased funding for all of science, rather than each discipline arguing for its own pot of money. But equally important, he noted, is the need for constituents to speak directly to their representatives about the need for strong support for science. In the current budget climate, "you have to be talking to your members," he said. "Because if you are not talking to them, there is someone who is who wants your money."

—*Allyn Jackson*

The NSF fiscal year 2005 budget request may be found on the web at `http://www.nsf.gov/bfa/bud/start.htm`.

Mathematical Sciences in the FY 2005 Budget

Samuel M. Rankin III

Highlights

- Federal support for the mathematical sciences is slated to grow from an estimated \$362.41 million in FY 2004 to an estimated \$374.45 million in FY 2005, an increase of 3.3 percent. This rate of increase is less than half of the rate of increase from FY 2003 to FY 2004.
- The National Science Foundation's (NSF) Division of Mathematical Sciences (DMS) would receive only a 0.9 percent increase, for a total of \$202.25 million in FY 2005 compared to an estimated \$200.41 million in FY 2004.
- The Defense Advanced Research Projects Agency (DARPA), a Department of Defense (DOD) agency, would grow by 7.0 percent, while the Army Research Office (ARO) mathematical sciences budget would increase by 5.3 percent. The National Security Agency (NSA) budget, although small compared to other DOD agencies, would grow by 16.7 percent.
- The Department of Energy (DOE) Applied Mathematics Division would receive a 29.6 percent increase, the largest percentage jump of all the agency budgets for the mathematical sciences.

Introduction

The mathematical sciences are funded through the National Science Foundation; the Department of Defense, including the National Security Agency; the Department of Energy; and the National Institutes of Health (NIH). In 2005 the majority of support for the mathematical sciences from all these agencies would come from the NSF, contributing 54.0 percent of the total. The DOD accounts for 21.3 percent of the total, with the NIH supplying 16.9 percent, and the DOE 7.8 percent. The NSF accounts for the majority of the support for academic research in the mathematical sciences and is the only agency that supports mathematics research broadly across all fields. The DOD, DOE, and NIH support research in the mathematical sciences that contributes to the research and development missions of these agencies.

The DOD has five programs supporting mathematical sciences research and related activities: the Directorate of Mathematics and Space Sciences within the Air Force Office of Scientific Research (AFOSR); the Mathematical Sciences Division within the Army Research Office; the Mathematical, Computer, and Information Sciences Division within the Office of Naval Research (ONR); the Applied and Computational Mathematics Program within the Defense Advanced Research Projects Agency; and the Mathematical Sciences Program within the National Security Agency.

The DOE funds mathematics through its Applied Mathematics program within the DOE Mathematical, Computational, and Computer Sciences Research program. The National Institutes of Health funds mathematical sciences research primarily through the National Institute of General Medical Sciences (NIGMS) and through the National Institute of Biomedical Imaging and Bioengineering (NIBIB).

Several other agencies have small amounts of funding for mathematics research as it relates to agency missions. These agencies include the National Aeronautics and Space Administration (NASA), the Environmental Protection Agency (EPA), and the National Institute of Standards and Technology (NIST).

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Trends in Federal Support for the Mathematical Sciences

The FY 2005 estimated aggregate spending for mathematical sciences research and related activities would be $374.45 million, a potential increase of 3.3 percent over FY 2004 estimated spending. The increase for the NSF would be the lowest in several years, severely impacting the overall federal support for the mathematical sciences. The increase at the DOE for FY 2005 would be a healthy 29.6 percent increase over the FY 2004 level. Other pleasant surprises would be the 7.0 percent increase at DARPA, the 5.3 percent increase at the ARO, and the 16.7 percent increase at the NSA.

In recent years, the NIH has increased support of the mathematical sciences. This is not surprising given the many areas where the mathematical sciences contribute to advances in biomedical research. This trend of contributing to research in the biomedical sciences—and to the biological sciences in general, for that matter—will be sustained in the future.

The mathematical sciences are making major contributions to the country's intellectual capacity, and the need for the mathematical sciences in scientific discovery and technological innovation is accelerating. Yet many mathematical scientists who perform excellent research and submit grant proposals deemed of very high quality are either not funded or are underfunded. According to the *Science and Engineering Indicators*, 2002 Edition, only 28.3 percent of full-time academic mathematicians receive federal research support. This is much lower than most other fields of science.

National Science Foundation (NSF)

For FY 2005 the mathematical sciences would continue to be an NSF-wide priority area. The foundation has budgeted $89.11 million to carry out the priority area activities in FY 2005, with $67.39 million of this amount coming from the DMS and the remaining $21.72 million coming from throughout the foundation. The NSF-wide allocation depends on cooperative funding opportunities with other NSF directorates and requires matching funds from the DMS. The mathematical sciences were first designated an NSF priority area in FY 2002, and currently this designation is planned to go through FY 2007. In FY 2006 the priority area is projected to receive approximately $90 million, and in FY 2007 approximately $92 million.

The DMS is slated to receive a budget of $202.25 million in FY 2005, only a 0.9 percent or $1.84 million increase over the FY 2004 level. This low increase is quite surprising given that the mathematical sciences are a priority area and given that advances in science and engineering rely more than ever on the mathematical sciences.

The FY 2005 increase in the DMS would:

- Maintain the investment in focused mathematical sciences research teams, interdisciplinary training groups, and other collaborative mechanisms related to advancing science and engineering.
- Enhance the national institutes in the mathematical sciences that address the growing interface with other disciplines and the mathematical and statistical problems whose solutions will contribute to both fundamental knowledge and national needs. In FY 2005 support for mathematical sciences research institutes would increase by $1.5 million over FY2004, rising from a total of $15.1 million to a total of $16.6 million.
- Enhance research training activities in the mathematical sciences and mentoring activities aimed at increasing the number of U.S. students choosing careers in the mathematical sciences. This would be achieved by a redistribution of funds from other targeted investments in people.

Air Force Office of Scientific Research (AFOSR)

The Directorate of Mathematics and Space Sciences provides funds for research in the mathematical sciences in support of the Air Force mission. Current program emphases include cooperative control, quantum computing, and Maxwell's equations. Beginning perhaps as early as FY 2005, a new initiative in nanoscience is anticipated. The AFOSR mathematics program includes specific portfolios in dynamics and control, physical mathematics and applied analysis, computational mathematics, optimization and discrete mathematics, systems and software, electromagnetics, and signals communication and surveillance. The AFOSR budget would increase slightly over FY 2004.

Army Research Office (ARO)

The Mathematical Sciences Division is divided into the following programs: applied analysis, computational mathematics, discrete mathematics and computer science, probability and statistics and stochastic analysis, and mathematical modeling and simulation. The Mathematical Sciences Division plays an essential role in the modeling, analysis, and control of complex phenomena and systems that are of critical interest to the army. The areas of application include ad hoc and wireless networks, image and scene analysis, and the testing and evaluation of new systems. The FY 2005 budget would increase by 5.3 percent over FY 2004.

Defense Advanced Research Projects Agency (DARPA)

DARPA's Applied and Computational Mathematics program activities are structured around two interrelated central themes: development of well-conditioned fast algorithms and strategies for the exploitation of high-dimensional data and mathematical modeling to enable virtual design. These themes are addressed through the six program areas: Integrated Sensing and Processing,

Table 1. Federal Funding for the Mathematical Sciences (millions of dollars)[1]

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change 2004–05 Amount	Change 2004–05 Percent
National Science Foundation					
DMS	$178.79	$200.41*	$202.25	$1.84	0.9%
Department of Defense					
AFOSR	$ 32.5	$ 30.0	$ 30.9	$0.9	3.0%
ARO	9.9	9.5	10.0	0.5	5.3
DARPA	16.3	21.5	23.0	1.5	7.0
NSA	3.0	3.0	3.5	0.5	16.7
ONR	10.5	12.5	12.4	0.1	-0.8
Total DOD	$ 72.2	$ 76.5	$ 79.8	$ 3.3	4.3%
Department of Energy					
Applied Mathematics	$ 21.3	$ 22.6	$ 29.3	$ 6.7	29.6%
National Institutes of Health					
NIGMS	$ 35.0**	$ 35.0**	$ 35.0**	$ 0.0	0.0%
NIBIB	27.0**	27.9**	28.1**	0.2	0.7
Total NIH	$ 62.0	$ 62.9	$ 63.1	$ 0.2	0.3%
Total All Agencies	$334.29	$362.41	$374.45	$12.04	3.3%

**This figure is estimated based on language in the FY 2004 Omnibus Appropriations Bill.*

***Estimates based on conversation with program manager. The NIGMS FY 2005 number is the author's best guess based on a conversation with an NIGMS representative last year.*

[1] Budget information comes from agency documents and conversations with agency program managers and representatives. DOD FY 2004 and FY 2005 numbers are estimates.

Time-Reversal Methods, Predicting Real Optimized Materials, Quantum Information Science and Technology, Geospatial Representation and Analysis, and Virtual Electromagnetic and Testrange. Additionally, DARPA has core mathematics activities supporting work in geometric Langlands and stochastic partial differential equations. The FY 2005 budget for the mathematical sciences would increase by 7.0 percent over FY 2004.

Department of Energy (DOE)

Mathematics is funded through the Applied Mathematics program of the Mathematical, Information, and Computational Sciences Division (MICS) of the DOE. Research is conducted on the underlying mathematical understanding of physical, chemical, and biological systems and advanced numerical algorithms that enable effective description and prediction of such systems on terascale computing systems. Research in applied mathematics supported by the MICS underpins computational science throughout the DOE. The FY 2005 budget for the Applied Mathematics Program continues the Computational Sciences Fellowship program at its current level of $3.5 million. The FY 2005 budget also includes $8.5 million for the new Atomic to Macroscopic Mathematics (AMM) research effort to provide the research support in applied mathematics needed for understanding complex physical processes that occur on a wide range of interacting length- and time-scales. Current state-of-the-art theory and modeling of complex physical systems require that the physical phenomena being modeled either occur at a single scale or widely separated scales with little or no interaction. The AMM effort will support university researchers, partnerships between universities and national laboratories, and multidisciplinary research teams at national laboratories. The Applied Mathematics Program FY 2005 budget would increase by $6.7 million over FY 2004.

National Institutes of Health (NIH)

The NIH funds mathematical sciences research through the National Institute of General Medical Sciences (NIGMS) and the National Institute of Biomedical Imaging and Bioengineering (NIBIB). Currently the NIGMS is supporting a biomathematics initiative in cooperation with the National Science Foundation. Mathematical sciences areas of interest are those that support the missions of the NIGMS and the NIBIB. These mission areas include population biology, system biology, macromolecular structures, and bioinformatics for the NIGMS; and computational science, model development, and bioinformatics for the NIBIB. Computational science includes development and application of theoretical methods, mathematical modeling, and computational simulation techniques in the study of biological systems. Bioinformatics includes research, development, and applications of informatics tools and approaches for expanding the use of biological, medical, behavioral, or health data, including those to acquire, store, organize, archive, analyze, or visualize data. The FY 2005 NIH budget supporting the mathematical sciences would grow slightly over FY 2004.

National Security Agency (NSA)

The NSA has a small grant program that supports fundamental research in the mathematical areas of algebra, number theory, discrete mathematics, probability, and statistics. The grant program also accepts proposals for miscellaneous conferences and workshops in these research areas. Additional funding is available to support Historically Black Colleges and Universities, Research Experiences for Undergraduates, and a faculty sabbatical leave program. The program administrators are especially interested in funding initiatives that encourage the participation of underrepresented groups in mathematics (such as women, African Americans, and other minorities). The NSA is the world's largest employer of mathematicians and is constrained to hire only U.S. citizens. As a result, the NSA has a special interest in encouraging more U.S. citizens to study mathematics. The FY 2005 NSA budget would increase by 16.7 percent over FY 2004.

Office of Naval Research (ONR)

The ONR Mathematical, Computer, and Information Sciences Division's scientific objective is to establish rigorous mathematical foundations and analytical and computational methods that enhance understanding of complex phenomena and enable prediction and control for naval applications in the future. Basic research in the mathematical sciences is focused on analysis and computation for multiphase, multimaterial, multiphysics problems; predictability of models for nonlinear dynamics; electromagnetic and acoustic wave propagation; signal and imaging processing; modeling pathological behaviors of large, dynamic complex networks and exploiting hybrid control to achieve reliability and security; optimization; and formal methods for verifiably correct software construction. The Mathematical, Computer, and Information Sciences Division's budget would decrease in FY 2005.

Note: Information gathered from agency documents and from agency representatives.

An opportunity to join a world-class African university

LECTURER/SENIOR LECTURER/ ASSOCIATE PROFESSOR: DEPARTMENT OF MATHEMATICS & APPLIED MATHEMATICS

The Department is a large and dynamic organization with an establishment of over thirtyfaculty members. We seek to make one new appointment.

Applications are sought for a post at all levels, from Lecturer to Associate Professor, in all fields compatible with the research interests of the Department, including enrichment programmes for schools (see Website: www.mth.ac.za for details of our research groups). We particularly encourage applications from candidates with research and teaching interests in one or more of the following: Algebra, Analysis (global analysis, functional analysis and dynamical systems), Geometry and Lie Theory. Applications are also welcome from candidates whose activities include the application of one or more of these disciplines to financial mathematics, industrial mathematics, physics or engineering.

Young mathematicians with interests in the above research areas are encouraged to apply. Applicants for a senior position should have good teaching and strong international research records, and the ability to raise research funding and develop strong research programmes in their fields of interest.

Level of appointment will be commensurate with the experience and standing of applications.

The remuneration packages are negotiable and include highly competitive benefits.

Please send a letter of application, clearly stating the post for which you are applying, the level of post and the reference number, your CV (no certificates), a one-page summary of your CV and details (email/fax) of 3 referees to: Staff Recruitment and Selection (Ref: 859), UCT, Rondebosch 7701, Cape Town, South Africa by 12 July 2004. Telephone: +27 21 650 2192, fax: +27 21 650 2138, email: mabalane@bremner.uct.ac.za

Website: www.uct.ac.za

UCT is fully committed to employment equity (http://web.uct.ac.za/misc/emequity/eep.htm) and particularly welcomes applications from suitably qualified black South Africans, women and persons with disabilities.

C6247/4359-R

UNIVERSITY OF CAPE TOWN

Mathematics People

2004–2005 AMS Centennial Fellowships Awarded

The AMS has awarded two Centennial Fellowships for 2004–2005. The recipients are Jinho Baik of the University of Michigan and Nitu Kitchloo of Johns Hopkins University. The amount of each fellowship is $60,000. The Centennial Fellows also receive an expense allowance of $1,700 and a complimentary Society membership for one year.

Jinho Baik

Jinho Baik received his Ph.D. in 1999 from the Courant Institute of Mathematical Sciences, New York University, under the direction of Percy Deift. He was a Veblen Instructor at Princeton University and the Institute for Advanced Study during 1999–2002, and an assistant professor at Princeton University during 2002–2003. Since 2002 he has been an assistant professor at the University of Michigan.

Baik has been applying methods from integrable systems to probability, combinatorics, and statistical physics. In particular, asymptotic problems on random matrices, random permutations and orthogonal polynomials, and their interrelations have been his main research interest.

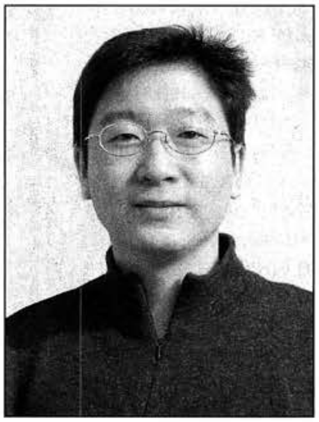
He plans to use the fellowship to visit the Courant Institute of Mathematical Sciences.

Nitu Kitchloo

Nitu Kitchloo received his Ph.D. in 1998 from the Massachusetts Institute of Technology under Haynes Miller. From 1998 to 2001 he was an instructor at Northwestern University, and from 2001 to the present he has been an assistant professor at Johns Hopkins University.

He plans to use his Centennial Fellowship at the University of California, San Diego (where he will assume the position of associate professor in fall 2004), and at Johns Hopkins University.

Kitchloo's research is in the fields of geometry, topology, and homotopy theory. He uses topological methods to study infinite-dimensional objects like loop spaces, loop groups, and Kac-Moody groups. His current interests involve studying the topology of symplectomorphism groups. He is also working on the topology of certain infinite loop spaces arising from spectra related to complex cobordism.



Jinho Baik

Nitu Kitchloo

Please note: Information about the competition for the 2005–2006 AMS Centennial Fellowships will be published in the "Mathematics Opportunities" section of an upcoming issue of the *Notices*.

—*Allyn Jackson*

Biran Awarded Oberwolfach Prize

Paul Biran of Tel Aviv University has received the 2003 Oberwolfach Prize for outstanding research in geometry and topology, particularly symplectic and algebraic geometry. The prize will be given on July 2, 2004, during the 60th anniversary celebration of the Mathematisches Forschungsinstitut Oberwolfach.

Paul Biran has made fundamental and influential contributions to symplectic topology as well as algebraic geometry. In his thesis he found a remarkable solution to the symplectic packing problem, i.e. the question of what percentage of the volume of a symplectic 4-manifold can be filled by a symplectic embedding of n disjoint balls of equal size. For small numbers of balls, obstructions have been known since the work of Gromov. Biran proved that full packing is possible for every symplectic 4-manifold provided that the number of balls is sufficiently large. His proof introduces original new techniques in symplectic topology: he showed that every symplectic manifold (with integral symplectic class) can be decomposed into a 2-disk bundle over a symplectic submanifold and an isotropic CW complex (on which the symplectic form vanishes). This structure theorem has many other consequences, such as intersection results for Lagrangian submanifolds (the "Lagrangian barrier" phenomenon discovered by Biran) and new obstructions to Lagrangian embeddings. Biran's work also provides new interconnections between symplectic and algebraic geometry: he was able to use symplectic techniques to obtain new results in algebraic geometry, including his contributions to the Nagata conjecture, and new obstructions for smooth projective varieties to appear as hyperplane sections of any other smooth variety or as sections in a fibration with isolated singularities. In another direction Paul Biran made some important contributions to the theory of periodic orbits of Hamiltonian systems as well as to the new theory of Calabi quasimorphisms on the group of Hamiltonian symplectomorphisms. His work covers a wide range of mathematics and brings together many deep and powerful techniques in symplectic topology, such as Floer homology, pseudoholomorphic curves, Donaldson's theory of symplectic submanifolds and Lefschetz pencils, and Seiberg-Witten invariants.

The Oberwolfach Prize is awarded by the Gesellschaft für Mathematische Forschung e.V. to European mathematicians not older than thirty-five years. The prize recognizes excellent achievements in a specific field of mathematics, which changes each time the prize is given. The prize carries a monetary award of 5,000 euros (approximately US$6,000).

Previous recipients of the Oberwolfach Prize are Peter Kronheimer (topology and geometry, 1991), Jörg Brüdern and Jens Franke (number theory and algebra, 1993), Gero Friesecke and Stefan Sauter (analysis and applied mathematics, 1996), Alice Guionnet (stochastics, 1999), and Luca Trevisan (discrete mathematics, 2000).

—Elaine Kehoe

Veneziano Awarded 2004 Heineman Prize

Gabriele Veneziano of CERN (European Organization for Nuclear Research) has been awarded the Dannie Heineman Prize for Mathematical Physics "for his pioneering discoveries in dual resonance models which, partly through his own efforts, have developed into string theory and a basis for the quantum theory of gravity."

The prize carries a cash award of $7,500 and is presented in recognition of outstanding publications in the field of mathematical physics. The prize was established in 1959 by the Heineman Foundation for Research, Educational, Charitable, and Scientific Purposes, Inc., and is administered jointly by the American Physical Society (APS) and the American Institute of Physics (AIP). The prize is presented annually.

—From an APS announcement

Friedman Wins 2004 Parzen Prize

The Emanuel and Carol Parzen Prize for Statistical Innovation for 2004 has been awarded to Jerome H. Friedman of Stanford University "for his significant innovations in statistical theory that have transformed practice by the creation of influential software, that have significantly influenced modern computational statistics, and that have provided seminal leadership and statistical foundations to research in data mining and knowledge discovery, machine learning and statistical learning, and nonparametric statistical methods."

The Parzen Prize is awarded in even-numbered years by the Department of Statistics at Texas A&M University to North American statisticians who have made outstanding and influential contributions to the development of applicable and innovative statistical methods. The prize consists of a $1,000 honorarium and travel to College Station, Texas, to present a lecture at the prize ceremony.

—Department of Statistics, Texas A&M University

Holroyd and Benjamini Awarded Rollo Davidson Prizes

The trustees of the Rollo Davidson Trust have awarded two Rollo Davidson Prizes for 2004. Ander Holroyd of the University of British Columbia was honored for his "novel contributions to different areas of probability, including percolation in its many forms." Itai Benjamini of the Weizmann Institute, Rehovot, Israel, was honored "for his work across probability, including the analytic and geometric, particularly in the study of random processes associated with graphs."

The prize was established to commemorate the life and work of Rollo Davidson and is awarded to young scientists of outstanding promise and achievements in probability, statistics, and related areas.

—From a Rollo Davidson Trust announcement

Brousseau and Hoyles Receive ICMI Medals

The International Commission on Mathematical Instruction (ICMI), founded in Rome in 1908, has, for the first time in its history, established prizes recognizing outstanding achievement in mathematics education research. The Felix Klein Medal, named for the first president of ICMI (1908–1920), honors a lifetime achievement. The Hans Freudenthal Medal, named for the eighth president of ICMI (1967–1970), recognizes a major cumulative program of research. These awards are to be made in each odd-numbered year, with presentation of the medals and invited addresses by the medalists at the following International Congress on Mathematical Education (ICME).

These awards, which pay tribute to outstanding scholarship in mathematics education, serve not only to encourage the efforts of others but also to contribute to the development, through the public recognition of exemplars, of high standards for the field. The awards represent the judgment of an (anonymous) jury of distinguished scholars of international stature, chaired by Michèle Artigue of the University Paris 7. Presentation of the medals and invited addresses of the medalists will occur at the International Congress of Mathematics Education in Copenhagen in July 2004.

Guy Brousseau

The Felix Klein Medal for 2003 is awarded to Guy Brousseau, professor emeritus of the University Institute for Teacher Education of Aquitaine in Bordeaux. This distinction recognizes the essential contribution Guy Brousseau has made to the development of mathematics education as a scientific field of research through his theoretical and experimental work over four decades, and the sustained effort he has made throughout his professional life to apply the fruits of his research to the mathematics education of both students and teachers.

Born in 1933, Guy Brousseau began his career as an elementary teacher in 1953. In the late 1960s, after graduating in mathematics, he entered the University of Bordeaux. In 1986 he earned a *doctorat d'état* and in 1991 became a full professor at the newly created University Institute for Teacher Education (IUFM) in Bordeaux, where he worked until 1998.

From the early 1970s Guy Brousseau emerged as one of the leading and most original researchers in the new field of mathematics education, convinced on the one hand that this field must be developed as a genuine field of research, with both fundamental and applied dimensions, and on the other hand that it must remain close to the discipline of mathematics. His notable theoretical achievement was the elaboration of the theory of *didactic situations*, a theory that he initiated in the early 1970s and that he has continued to develop with unfailing energy and creativity. At a time when the dominant vision was cognitive, strongly influenced by the Piagetian epistemology, he stressed that what the field needed for its development was not a purely cognitive theory but one allowing us also to understand the social interactions between students, teachers, and knowledge that take place in the classroom and that condition what and how students learn. This is the aim of the theory of didactic situations, which has progressively matured, becoming the impressive and complex theory that it is today. To be sure, this was a collective work, but each time there were substantial advances the critical source was Guy Brousseau.

Although the research Guy Brousseau has inspired currently embraces the entire range of mathematics education from elementary to postsecondary, his major contributions deal with the elementary level, where they cover all mathematical domains, from numbers and geometry to probability. Their production owes much to the COREM (Center for Observation and Research in Mathematics Education), which he created in 1972 and directed until 1997. COREM provided an original organization of the relationships between theoretical and experimental work.

Guy Brousseau is not only an exceptional and inspired researcher in the field, he is also a scholar who has dedicated his life to mathematics education, tirelessly supporting the development of the field, not only in France, but in many countries, supporting new doctoral programs, helping and supervising young international researchers (he supervised more than fifty doctoral theses), and contributing in a vital way to the development of mathematical and didactic knowledge of students and teachers.

Celia Hoyles

The Hans Freudenthal Medal for 2003 is awarded to Celia Hoyles, professor at the Institute of Education of the University of London, for her seminal research on instructional uses of technology in mathematics education. This distinction recognizes the outstanding contribution that Celia Hoyles has made to research in the domain of technology and mathematics education.

Celia Hoyles studied mathematics at the University of Manchester, winning the Dalton prize for the best first-class degree in mathematics. She began her career as a secondary teacher and then became a lecturer at the Polytechnic of North London. She entered the field of mathematics education research, earning a master's degree and doctorate, and became professor of mathematics education at the Institute of Education, University of London, in 1984.

Her early research in the area of technology and mathematics education, like that of many researchers, began by exploring the potential offered by Logo, and she soon became an international leader in this area. Her book, *Windows on Mathematical Meanings: Learning Cultures and Computers*, coauthored with Richard Noss, inspired major theoretical advances in the field, such as the notions of webbing and situated abstraction, ideas that are well known to researchers irrespective of the specific technologies they are studying. From the mid-1990s her research on technology integrated the new possibilities offered by information and communication technologies as well as the new relationships children develop with technology. As an international leader in the area of technology and mathematics education, she was recently appointed by the ICMI Executive Committee as cochair of a new ICMI study on this theme.

Celia Hoyles' contribution to research in mathematics education is considerably broader than this focus on technology. Since the mid-1990s she has been involved in two further major areas of research. The first, a series of studies on children's understanding of proof, has pioneered some novel methodological strategies linking quantitative and qualitative approaches that include longitudinal analyses of development. The second area has involved researching the mathematics used at work, and she now co-directs a new project, Techno-Mathematical Literacies in the Workplace, which aims to develop this research by implementing and evaluating some theoretically designed workplace training using a range of new media.

In recent years Celia Hoyles has become increasingly involved in working alongside mathematicians and teachers in policymaking. She was elected chair of the Joint Mathematical Council of the U.K. in October 1999, and she is a member of the Advisory Committee on Mathematics Education (ACME), which speaks for the whole of the mathematics community to the government on policy matters related to mathematics education, from primary to higher education. In recognition of her contributions, she has recently been awarded the Order of the British Empire for "Services to Mathematics Education".

Celia Hoyles belongs to that special breed of mathematics educators who, even while engaging with theoretical questions, do not lose sight of practice and, reciprocally, while engaged in advancing practice, do not forget the lessons they have learned from theory and from empirical research.

—from an ICMI Announcement

Sloan Fellows Announced

The Alfred P. Sloan Foundation has announced the names of 116 outstanding young scientists and economists who have been selected to receive Sloan Research Fellowships. Grants of $40,000 for a two-year period are administered by each fellow's institution. Once chosen, fellows are free to pursue whatever lines of inquiry most interest them, and they are permitted to employ fellowship funds in a wide variety of ways to further their research aims. More than 500 nominations for the 2004 awards were reviewed by a committee of distinguished scientists. The mathematicians on the committee were Benedict Gross, Harvard University; George Papanicolaou, Stanford University; and Ronald Stern, University of California, Irvine.

Following are the names of the 2004 Sloan Fellows who work in the mathematical sciences: MEREDITH D. BETTERTON, University of Colorado; ROMAN BEZRUKAVNIKOV, Northwestern University; KENNETH BROMBERG, University of Utah; LI-TIEN CHENG, University of California, San Diego; NATHAN M. DUNFIELD, California Institute of Technology; THOMAS J. HAINES, University of Maryland, College Park; VADIM KALOSHIN, California Institute of Technology; ROWAN KILLIP, University of California, Los Angeles; MARK KISIN, University of Chicago; IOANNIS KONTOYIANNIS, Brown University; LEI NI, University of California, San Diego; ROBERT SEIRINGER, Princeton University; KNUT SOLNA, University of California, Irvine; BENNY SUDAKOV, Princeton University; JEFF VIACLOVSKY, Massachusetts Institute of Technology; BALINT VIRAG, University of Toronto; DIVAKAR VISWANATH, University of Michigan; KEVIN WHYTE, University of Illinois, Chicago; AE JA YEE, Pennsylvania State University; CHONGCHUN ZENG, University of Virginia.

—From a Sloan Foundation announcement

NSF Graduate Research Fellowships Announced

The National Science Foundation (NSF) has awarded its Graduate Research Fellowships for fiscal year 2004. This program supports students pursuing doctoral study in all areas of science and engineering and provides a stipend of $18,000 per year for three years of full-time graduate study. Following are the names of the awardees in the mathematical sciences for 2004, followed by their undergraduate institutions (in parentheses) and the institutions at which they plan to pursue graduate work.

BENJAMIN ARMBRUSTER (University of Arizona), Massachusetts Institute of Technology; MARGARET S. BRISCOE (Tulane University-Newcomb College), University of California, Berkeley; JONATHAN H. BROWN (Vanderbilt University), Vanderbilt University; EVAN M. BULLOCK (Rice University), Harvard University; ERIK L. CARLSSON (Stanford University), Princeton University; DAVID A. CONSTANTINE (Eastern Nazarene College), Cornell University; DAVID J. GAEBLER (Harvey Mudd College), University of California, Berkeley; JANE GU (Seoul National University), Massachusetts Institute of Technology; MATTHEW T. HOLDEN (Pomona College), Massachusetts Institute of Technology; RYAN C. HYND (Georgia Institute of Technology), Stanford University; DIANA L. ISTOOK (Brigham Young University), University of Oklahoma; JESSE KASS (University of Michigan), Harvard University; MICHAEL J. KHOURY (Denison University), Princeton University; WAI KEI PETER LEE (Stanford University), Massachusetts Institute of Technology; BRIAN T. LEHMANN (Yale University), University of California, Berkeley; PO-SHEN LOH (California Institute of Technology), Massachusetts Institute of Technology; JOEL LOS (University of Paris VII), University of California, Berkeley; ANI W. MANICHAIKUL (Stanford University), Johns Hopkins University; BERNARD A. MARES (Brown University) Stanford University; PHILIP J. MATCHETT (Harvard University), University of California, Berkeley; MAKSIM I. MAYDANSKIY (University of California, Berkeley), Massachusetts Institute of Technology; RADU H. MIHAESCU (Princeton University), University of California, Berkeley; DAVID K. MILOVICH (Massachusetts Institute of Technology), University of Wisconsin, Madison; ANTHONY J. NARKAWICZ (Virginia Polytechnic Institute and State University), Duke University; ANDREW G. NIEDERMAIER (Harvey Mudd College), University of California, Berkeley; Jennifer S. Novak (Texas A&M University), University of Chicago; Dimitri J. Papageorgiou (University of North Carolina, Chapel Hill), University of Texas, Austin; Ankit B. Patel (Harvard University), Massachusetts Institute of Technology; Jonathan L. Pottharst (Massachusetts Institute of Technology), Harvard University; Alexander B. Schwartz (Harvard University), Princeton University; James G. Scott (University of Texas, Austin), Duke University; Aleksandr G. Skorokhod (Massachusetts Institute of Technology), University of California, Berkeley; David I. Smyth (University of Illinois, Urbana-Champaign), University of California, Berkeley; John T. Workman (University of Tennessee, Knoxville), Stanford University.

Editor's note: The institutions of graduate study listed here are from the students' original applications. In some cases students will have switched institutions by the time the fellowship tenure begins.

—From an NSF announcement

Fulbright Awards Announced

The J. William Fulbright Foundation and the United States Information Agency have announced the names of the recipients of the Fulbright Foreign Scholarships for 2003–2004. Following are the U.S. scholars in the mathematical sciences who have been awarded Fulbright scholarships to lecture or conduct research, together with their home institutions and the countries in which they plan to use the awards.

Subha Chakraborti (University of Alabama, Tuscaloosa), South Africa; Abderrahmn Elkhader (Northern State University, South Dakota), Jordan; John B. Fink (Kalamazoo College), Ecuador; Dennis J. Garity (Oregon State University), Slovenia; Jason C.-H. Hsu (Ohio State University), Iceland; Anatoli F. Ivanov (Pennsylvania State University), Chile; Naihuan N. Jing (North Carolina State University), Germany; Joseph B. Kadane (Carnegie-Mellon University), Chile; Christopher M. Kribs Zaleta (University of Texas, Arlington), Mexico; Victor V. Pambuccian (Arizona State University), Poland; Rahul A. Parsa (Drake University), South Africa; Christopher P. Thron (Motorola), Chad; Frederi G. Viens (Purdue University), France.

—From a Fulbright Foundation announcement

Guggenheim Fellowships Awarded

The John Simon Guggenheim Memorial Foundation has announced the names of 185 United States and Canadian artists, scholars, and scientists who were selected as Guggenheim Fellows from more than 3,200 applicants in the 2004 competition. The awards totaled $6,912,000. Guggenheim Fellows are appointed on the basis of distinguished achievement in the past and exceptional promise for future accomplishment.

Following are the names of the awardees in the mathematical sciences, together with their affiliations and areas of research interest: Amir D. Aczel, Brookline, Massachusetts: Descartes's missing notebook and the beginnings of modern mathematics; Michael P. Brenner, Harvard University: Mathematical models in developmental biology; Huai-Dong Cao, Lehigh University: The Ricci flow on Kähler manifolds; Panagiota Daskalopoulos, Columbia University: Studies in nonlinear diffusion equations; Russell Impagliazzo, University of California, San Diego: Heuristics, proof complexity, and algorithmic techniques; Michael T. Lacey, Georgia Institute of Technology: Singular integrals on smoothly varying lines; William R. Zame, University of California, Los Angeles: Theoretical and experimental studies of financial markets; David Zuckerman, University of Texas, Austin: Randomness and computation. In addition, mathematician Manil Suri of the University of Maryland, Baltimore County, received a fellowship for the writing of fiction.

—From a Guggenheim Foundation news release

Intel Science Talent Search Winners Announced

Two high school students working in mathematics and one in physics have been awarded Intel Science Talent Search Scholarships for 2004. Boris Alexeev, a seventeen-year-old student at Cedar Shoals High School in Athens, Georgia, won the second prize, a $75,000 scholarship. The title of Alexeev's project is "Minimal Deterministic Finite Automata (DFSAs) for Testing Divisibility". He has submitted his work for publication. Linda B. Westrick, an eighteen-year-old student at Maggie L. Walker Governor's School in Richmond, Virginia, won fourth place and a $25,000 scholarship for her mathematics project "Investigations of the Number Derivative". Eduard Reznik, a seventeen-year-old student at Ward Melville High School in East Setauket, New York, won a $25,000 fifth-place scholarship for his physics project "New Exact Solutions to Einstein's Equations".

—From an Intel Corporation announcement

National Academy of Sciences Elections

The National Academy of Sciences has announced the election of 72 new members and 18 foreign associates in recognition of their distinguished and continuing achievements in original research.

Among the new members are several who work in the mathematical sciences: Joseph Bernstein, professor, School of Mathematical Sciences, Tel Aviv University; Phillip Colella, senior staff mathematician and group leader, Applied Numerical Algorithms Group, Lawrence Berkeley National Laboratory; Stephen H. Davis, McCormick School Professor and Walter P. Murphy Professor of Applied Mathematics, Northwestern University; Shafrira Goldwasser, professor, Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology; Benedict H. Gross, George Vasmer Leverett Professor of Mathematics, Department of Mathematics, and Dean, Harvard College, Harvard University; Nicholas M. Katz, professor and chair, Department of Mathematics, Princeton University; Charles M. Newman, professor of mathematics and director, Courant Institute of Mathematical Sciences, New York University; George F. Oster, professor of cell and developmental biology and of environmental science, policy, and management, University of California, Berkeley; and Ronald L. Rivest, professor of computer science, Massachusetts Institute of Technology.

—From an NAS news release

National Academy of Engineering Elections

The National Academy of Engineering has announced the election of 76 new members and 11 foreign associates, including four whose work involves the mathematical sciences. Frank T. Leighton of the Massachusetts Institute of Technology was elected for contributions to the design of networks and circuits and for technology for Web content delivery. Linda R. Petzold of the University of California, Santa Barbara, was elected for advances in the numerical solution of differential/algebraic equations and their incorporation into widely distributed software. G. W. Stewart of the University of Maryland, College Park, was elected for the development of numerical algorithms and software widely used in engineering computation. Elected as a foreign associate was John R. Willis of the University of Cambridge, United Kingdom, for contributions to the micromechanics of engineering materials and the establishment of rigorous bounds on the properties of nonlinear composites.

—From a National Academy of Engineering announcement

Chair of Pure Mathematics

Monash University, Melbourne, Australia

Monash University is seeking to appoint an outstanding scholar as professor to provide leadership in research and teaching in pure mathematics in the School of Mathematical Sciences within the university's Faculty of Science.

The School of Mathematical Sciences, consisting of 25 academic staff, has principal research interests in algebra and discrete mathematics, analysis and geometry, applied statistics and probability, astrophysics and general relativity, meteorology and geophysical fluid dynamics and computational mathematics. The school has a distinguished reputation for research and teaching and for many years has had one of the largest cohorts of honours and postgraduate students amongst schools of mathematical sciences at Australian universities.

The appointee will be expected to: provide leadership for pure mathematics in the School of Mathematical Sciences; undertake high quality research in pure mathematics; assist the school in broadening its offerings in the teaching of mathematics; attract and supervise higher degree students in pure mathematics; facilitate engagement with the wider university, other universities and the community.

The successful candidate will have an outstanding, internationally recognised record of research in an area of pure mathematics. Applicants with expertise that would support the current research strengths of the school are particularly encouraged. The appointee will be an accomplished teacher and will have proven administrative and leadership skills.

Professorial salary: $A106,327 per annum. Superannuation, travel and removal allowances are available.

Selection documentation may be accessed electronically on the world wide web: http://www.adm.monash.edu.au/sss/pc/jobads/jo_senior.htm

Confidential inquiries may be made to Associate Professor Alan Pryde, Head, School of Mathematical Sciences, telephone +61 3 9905 4438, facsimile +61 3 9905 5020, email head.maths@sci.monash.edu.au

Further information and particulars of the application procedure may be obtained from Mr John Noonan, Manager (Senior Appointments), Monash University, Victoria 3800, Australia, telephone +61 3 9905 5904, facsimile +61 3 9905 6857, email john.noonan@adm.monash.edu.au

Applications should reach Mr Peter Marshall, Divisional Director, Student and Staff Services, Monash University, Victoria 3800, Australia, no later than Friday, 2 July 2004.

The university reserves the right to appoint by invitation.

Monash respects the privacy of your personal information. For more details visit www.privacy.monash.edu.au

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Mathematics Opportunities

NSF CAREER Program Guidelines Available

The guidelines for the Faculty Early Career Development (CAREER) Program of the National Science Foundation (NSF) are now available on the World Wide Web. The program solicitation number is NSF 02-111. Information is available at `http://www.nsf.gov/pubs/2002/nsf02111/nsf02111.htm`. Proposals must be submitted electronically. The deadline for proposals in the mathematical and physical sciences is **July 22, 2004**.

—*From an NSF announcement*

Joint Initiative in Mathematical Biology

The Division of Mathematical Sciences and the Directorate for Biological Sciences of the National Science Foundation (NSF) and the National Institute of General Medical Sciences (NIGMS) at the National Institutes of Health have announced a collaborative initiative to support research in mathematics and statistics related to mathematical biology research.

The competition is designed to support research on mathematical problems related to biological problems in areas supported by the NSF and the NIGMS. A direct relationship between a biological application and mathematics is expected. Research teams that include scientists from both the life sciences community and the mathematical sciences community are encouraged. Both new and existing collaborations will be supported. Award sizes are expected to range from $100,000 to $400,000 per year with durations of 4–5 years.

The deadline for full proposals is **June 30, 2004**. For further information see the NSF website at `http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf04572`, or contact the program director for the Division of Mathematical Sciences, Michael H. Steuerwalt, email: `msteuerw@nsf.gov`.

—*From an NSF announcement*

Clay Senior Scholars Program

The Clay Mathematics Institute (CMI) has announced a Senior Scholars Program to foster mathematical research and the exchange of ideas by providing support for senior mathematicians who will play a central role in a topical program at an institute or university. Senior scholars will be appointed for residences of from one to three months, although terms of up to six months are possible.

Nomination materials include a letter of nomination, a curriculum vitae and publication list, and letters of reference. The deadline date for nominations is **August 1, 2004**. Materials should be sent to the attention of Maria McLaughlin, email: `nominations@claymath.org`, or to the Clay Mathematics Institute, One Bow Street, Cambridge, MA 02138. For further information, see the CMI website: `http://www.claymath.org/senior_scholars`, or call 617-995-2600.

—*From a CMI announcement*

Call for Nominations for Sloan Fellowships

Nominations for candidates for Sloan Research Fellowships, sponsored by the Alfred P. Sloan Foundation, are due by **September 15, 2004**. A candidate must be a member of the regular faculty at a college or university in the United States or Canada and must be at an early stage in his or her research career. For information, write to: Sloan Research Fellowships, Alfred P. Sloan Foundation, 630 Fifth Avenue, Suite 2550, New York, NY 10111, or consult the foundation's Web page: `http://www.sloan.org/programs/fellowship_brochure.shtml`.

—From a Sloan Foundation announcement

Call for Nominations for AWM Hay and Schafer Awards

The Executive Committee of the Association for Women in Mathematics (AWM) is calling for nominations for the Louise Hay Award for Contributions to Mathematics Education and the Alice T. Schafer Mathematics Prize.

The Louise Hay Award is intended to recognize outstanding achievements in any area of mathematics education, interpreted in the broadest possible sense. The award is presented annually to highlight the importance of mathematics education and to evoke the memory of all that Hay exemplified as a teacher, scholar, administrator, and human being. The nomination document(s) should include: (1) a one- to three-page letter of nomination highlighting the exceptional contributions of the candidate; (2) a curriculum vitae of the candidate, not exceeding three pages; and (3) three letters supporting the nomination. It is strongly recommended that the letters represent a range of constituents affected by the nominee's work.

The Alice T. Schafer Prize is awarded to an undergraduate woman for excellence in mathematics. The nominee may be at any level in her undergraduate career but must either be a U.S. citizen or have a U.S. school address. A letter of nomination for the Schafer Prize should include, but not be limited to, an evaluation of the nominee on the following criteria: (1) quality of performance in advanced mathematics courses and special programs, (2) demonstration of real interest in mathematics, (3) ability to do independent work in mathematics, and (4) performance in mathematical competitions at the local or national level, if any. A copy of transcripts and an indication of the candidate's undergraduate level should be included with a letter of nomination. Supporting materials (e.g., reports from summer work using mathematics, copies of talks given in student chapters, recommendations, etc.), if applicable, should be enclosed with the nomination.

Five complete copies of nomination material for these awards should be sent to either: The Hay Award Selection Committee or The Alice T. Schafer Award Selection Committee, Association for Women in Mathematics, 4114 Computer & Space Sciences Building, University of Maryland, College Park, MD 20742-2461. For further information call the AWM at 301-405-7892 or send email to `awm@math.umd.edu`. The AWM's Web address is `http://www.awm-math.org`.

Please note that nominations via email or fax are not acceptable. The deadline for nominations for both awards to be received at the AWM office is **October 1, 2004**.

—AWM announcement

News from the IMA

The Institute for Mathematics and its Applications (IMA) at the University of Minnesota has announced a thematic program on "Mathematics of Materials and Macromolecules: Multiple Scales, Disorder, and Singularities", to be held from September 2004 through June 2005.

The program is aimed at synthesizing the problems at the interface between mathematics, materials science, condensed matter physics, and biology. The program will particularly focus on phenomena that require modeling that integrates the atomic to the continuum scales.

A variety of tutorials and workshops will be offered. Activities for the fall quarter include: *September 20–24, 2004:* Tutorial on Mathematics of Materials. *September 27–October 1, 2004:* Workshop on Modeling of Soft Matter. *October 25–29, 2004:* Workshop on Singularities in Materials. *November 5–6, 2004:* Symposium on Prospects for Mathematics and Mechanics upon the 80th Birthday of Jerry Ericksen. *November 18–20, 2004:* Workshop on Future Challenges in Multiscale Modeling and Simulation.

Several focus groups will meet throughout the year on topics such as Multiscale Modeling and Computing, Soft Matter, and Singularities. The organizing committee for the year consists of Maria Carme T. Calderer, University of Minnesota; Richard D. James, University of Minnesota; Robert V. Kohn, New York University; Mitchell Luskin, University of Minnesota; John H. Maddocks, Swiss Federal Institute of Technology; Rob Phillips, California Institute of Technology; James P. Sethna, Cornell University; and Chris Wolverton, Ford Research Laboratory. For further information and application forms, see `http://www.ima.umn.edu/matter`.

—IMA announcement

News from BIRS

The Banff International Research Station for Mathematical Innovation and Discovery (BIRS) is a collaborative Canada-United States venture that provides an environment for creative interaction and the exchange of ideas, knowledge, and methods within the mathematical sciences and with related sciences and industry.

The principal activity sponsored by BIRS is five-day workshops, but two-day collaborations are also possible for industry and academic researchers to work together in teams or focused research groups for periods of two to four weeks. BIRS also hosts summer schools and graduate training camps.

Nassif Ghoussoub of the University of British Columbia was recently appointed scientific director for a period of three years, starting January 1, 2004. Ghoussoub is the founding director of the Pacific Institute for the Mathematical Sciences (PIMS) and a cofounder of BIRS.

For more information and a calendar of events for 2005, see `http://www.pims.math.ca/birs/`.

—From a BIRS announcement

Inside the AMS

Hawkins Presents Testimony

On March 25, 2004, Jane Hawkins, chair of the AMS Committee on Science Policy, presented testimony in support of the fiscal year 2005 appropriations for the National Science Foundation (NSF). The testimony was given before the subcommittee on Veterans' Affairs, Housing and Urban Development, and Independent Agencies of the House Committee on Appropriations. The NSF falls under the aegis of this subcommittee. Also presenting testimony were representatives of the American Chemical Society, the American Physical Society, and the Federation of American Societies for Experimental Biology. What follows is the text of Hawkins's testimony.

Mr. Chairman, Mr. Mollohan, and members of the subcommittee, the NSF is one of our nation's most important agencies for promoting and funding scientific, mathematical, and engineering research and education. This support is across all fields of science, as well as for interdisciplinary partnerships and new frontiers of scientific inquiry, such as nanotechnology.

Many new products, procedures, and methods have accrued from the NSF investment in basic research. These innovations came out of inquiries in quite a different context, often just scientific discovery. Research of this kind is essential to breakthroughs relevant to our modern world even though at the time of discovery relevance is not even suspected. To illustrate: much of the theoretical machinery developed during the latter part of the twentieth century to solve the three-hundred-year-old mathematics problem, Fermat's Theorem, is now finding its way into the construction of codes for secure communication. The mathematicians developing this theory were not thinking of secure communication codes; they were trying to solve a famous mathematical problem. Fourier series, developed over one hundred years ago as a way to represent functions, has a modern-day equivalent, wavelets, that has been instrumental in image restoration, including military applications.

The recent budget request proposes only a 0.6 percent increase in the overall federal basic research budget of the U.S. The nonmedical federal basic research budget will decline by 2.5 percent in FY 2005. NSF is an important agency for supporting basic research; in fact, although the NSF accounts for only 4.0 percent of federal spending for research and development, it supports nearly 50.0 percent of the nonmedical basic research at our colleges and universities.

James Mitchell (American Chemical Society) and Jane Hawkins (American Mathematical Society) testifying in support of fiscal 2005 appropriations for NSF.

Federal support, broadly across all disciplines, is critical for the U.S. scientific enterprise to remain healthy and to be a contributor to innovation twenty to thirty years from now. Neglect of basic inquiry over time will inhibit the growth of innovation and affect the country's economic stability as well as our national security. I urge the subcommittee to make an effort to increase the NSF budget substantially over the budget request level, thereby helping to establish an FY 2005 U.S. basic research budget that will sustain an optimum level of innovation.

—AMS Washington office

Retirement of Bernard R. McDonald

At its meeting in April 2004, the AMS Committee on Science Policy (CSP) held a brief event to honor Bernard R. McDonald, who, after more than twenty years of service, recently retired from the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF).

McDonald received his Ph.D. from Michigan State University in 1968. He was at the University of Oklahoma for sixteen years before joining the DMS staff in 1983 as a program director for the Algebra and Number Theory program. He also served as head of the Office of Special Projects and was executive officer/deputy director from 1988 until his retirement. During 1995–96 he served on detail in the office of the NSF director. From the fall of 2002 until his retirement he served on detail as a senior advisor in the NSF Budget Division, where he handled NSF assessment activities.

McDonald was awarded the Director's Distinguished Service Award (1999) and the Director's Meritorious Service Award (1995), which represent the two highest honors conferred by the foundation on its employees.

Among those making comments during the CSP event were acting DMS executive officer, Deborah Lockhart, and McDonald's longtime NSF colleague and former DMS director, Judith Sunley. Also making remarks were AMS president David Eisenbud of the Mathematical Sciences Research Institute in Berkeley, AMS executive director John H. Ewing, and CSP chair Jane Hawkins of the University of North Carolina, Chapel Hill. They praised McDonald's sound, sure judgment, his integrity, and his unflappability.

McDonald was given a framed certificate with the following text.

"The Committee on Science Policy of the American Mathematical Society expresses its profound gratitude to Bernard R. McDonald for his devoted service to mathematics and to the community of mathematicians. Through his dedicated work for more than twenty years at the National Science Foundation, Dr. McDonald has guided programs with a steady hand and has provided wise counsel to mathematicians everywhere. His level-headed insight and influence will be missed by all.

"The members of the Committee on Science Policy appreciate all that he has accomplished, and offer Dr. McDonald their special thanks and heartfelt good wishes for a happy and well-deserved retirement."

—*Allyn Jackson*

Deaths of AMS Members

AGNES BERGER, retired associate professor, Mt. Sinai Medical Center, died on March 27, 2002. Born on November 9, 1916, she was a member of the Society for 59 years.

WILLEM J. BLOK, professor, University of Illinois at Chicago, died on November 30, 2003. Born on February 22, 1947, he was a member of the Society for 32 years.

JOHN W. CARLSON, dean, University of South Dakota, died on June 1, 2003. Born on November 10, 1940, he was a member of the Society for 31 years.

SUBINOY CHAKRAVARTY, research consultant, Michigan State University, died on February 17, 2004. Born on July 18, 1946, he was a member of the Society for 20 years.

WILLIAM G. CHINN, emeritus, from San Francisco, CA, died on March 23, 2004. Born on May 26, 1919, he was a member of the Society for 45 years.

ELIAS DEEBA, professor, University of Houston-Downtown, died in February 2004. Born on December 15, 1949, he was a member of the Society for 29 years.

J. C. E. DEKKER, professor emeritus, Rutgers University, died on April 3, 2004. Born on September 6, 1921, he was a member of the Society for 53 years.

A. YA. DOROGOVTSEV, professor, Kiev, Ukraine, died on April 22, 2004. Born on September 7, 1935, he was a member of the Society for 25 years.

ALBERTO R. GALMARINO, professor emeritus, Northeastern University, died on March 18, 2004. Born on September 23, 1928, he was a member of the Society for 43 years.

WALTER GOTTSCHALK, of Providence, RI, died on February 15, 2004. Born on November 3, 1918, he was a member of the Society for 63 years.

MARTIN GUTERMAN, professor, Tufts University, died on February 1, 2004. Born on November 18, 1941, he was a member of the Society for 42 years.

VELMER HEADLEY, professor, Brock University, Canada, died on March 24, 2004. Born on September 7, 1934, he was a member of the Society for 38 years.

CLAIBORNE M. JAMES of Longmont, CO, died on November 23, 2003. He was a member of the Society for 4 years.

ROBERT M. KAUFFMAN, professor, University of Alabama at Birmingham, died on February 8, 2004. Born on August 26, 1941, he was a member of the Society for 38 years.

OLGA A. LADYZHENSKAYA, professor and chair, Russian Academy of Sciences, Steklov Mathematical Institute, died on January 12, 2004. Born on March 7, 1922, she was a member of the Society for 9 years.

DAVID A. PAGE, professor, University of Illinois at Chicago, died on January 29, 2004. Born in 1925, he was a member of the Society for 28 years.

MARVIN ROSENBLUM, professor emeritus, University of Virginia, died on November 19, 2003. Born on June 30, 1926, he was a member of the Society for 48 years.

CAREL L. SCHEFFER, retired, Delft University of Technology, The Netherlands, died on January 13, 2004. Born on October 9, 1928, he was a member of the Society for 40 years.

R. SUBRAMANIAN, professor emeritus, Indian Institute of Technology, died in December 2003. Born on September 15, 1937, he was a member of the Society for 8 years.

NORMAN WESLEY TORGERSON, retired, from Long Beach, CA, died on October 10, 2003. Born on April 30, 1925, he was a member of the Society for 23 years.

HERBERT VOEGE, professor, Ferris State University, died on January 9, 2004. Born on April 18, 1929, he was a member of the Society for 24 years.

GEORGE W. WHITEHEAD JR., professor emeritus, Massachusetts Institute of Technology, died on April 12, 2004. Born on August 2, 1918, he was a member of the Society for 65 years.

CHARLES W. WILLIAMS, professor emeritus, Washington & Lee University, died on October 25, 2003. Born on March 24, 1912, he was a member of the Society for 38 years.

BERTRAM YOOD, professor emeritus, Pennsylvania State University, died on March 17, 2004. Born on January 6, 1917, he was a member of the Society for 62 years.

Reference and Book List

*The **Reference** section of the* Notices *is intended to provide the reader with frequently sought information in an easily accessible manner. New information is printed as it becomes available and is referenced after the first printing. As soon as information is updated or otherwise changed, it will be noted in this section.*

Contacting the *Notices*

The preferred method for contacting the *Notices* is electronic mail. The editor is the person to whom to send articles and letters for consideration. Articles include feature articles, memorial articles, communications, opinion pieces, and book reviews. The editor is also the person to whom to send news of unusual interest about other people's mathematics research.

The managing editor is the person to whom to send items for "Mathematics People", "Mathematics Opportunities", "For Your Information", "Reference and Book List", and "Mathematics Calendar". Requests for permissions, as well as all other inquiries, go to the managing editor.

The electronic-mail addresses are `notices@math.ou.edu` in the case of the editor and `notices@ams.org` in the case of the managing editor. The fax numbers are 405-325-7484 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Information for *Notices* Authors

The *Notices* welcomes unsolicited articles for consideration for publication, as well as proposals for such articles. The following provides general guidelines for writing *Notices* articles and preparing them for submission.

***Notices* readership.** The *Notices* goes to about 30,000 subscribers worldwide, of whom about 20,000 are in North America. Approximately 8,000 of the 20,000 in North America are graduate students who have completed at least one year of graduate school. All readers may be assumed to be interested in mathematics research, but they are not all active researchers.

***Notices* feature articles.** Feature articles may address mathematics, mathematical news and developments, mathematics history, issues affecting the profession, mathematics education at any level, the AMS and its activities, and other such topics of interest to *Notices* readers. Each

Where to Find It

A brief index to information that appears in this and previous issues.

AMS Bylaws—*November 2003, p. 1283*

AMS Email Addresses—*November 2003, p. 1266*

AMS Ethical Guidelines—*June/July 2004, p. 675*

AMS Officers 2002 and 2003 (Council, Executive Committee, Publications Committees, Board of Trustees)—*May 2004, p. 566*

AMS Officers and Committee Members—*October 2003, p. 1115*

Backlog of Mathematics Research Journals—*September 2003, p. 961*

Conference Board of the Mathematical Sciences—*September 2003, p. 945*

Information for *Notices* Authors—*June/July 2004, p. 670*

Mathematics Research Institutes Contact Information—*August 2003, p. 821*

National Science Board—*January 2004, p. 54*

New Journals for 2003—*June/July 2004, p. 672*

NRC Board on Mathematical Sciences and Their Applications—*March 2004, p. 350*

NRC Mathematical Sciences Education Board—*April 2004, p. 446*

NSF Mathematical and Physical Sciences Advisory Committee—*February 2004, p. 242*

Program Officers for Federal Funding Agencies—*October 2003, p. 1107 (DoD, DoE); December 2003, p. 1429 (DMS Program Officers); December 2003, p. 1430 (NSF Education Program Officers)* article is expected to have a large target audience of readers, perhaps 5,000 of the 30,000 subscribers. Authors must therefore write their articles for nonexperts rather than for experts or would-be experts. In particular, the mathematics articles in the *Notices* are expository. The language of the *Notices* is English.

Most feature articles, including those on mathematics, are expected to be of long-term value and should be written as such. Ideally each article should put its topic in a context, providing some history and other orientation for the reader and, as necessary, relating the subject matter to things that readers are likely to understand. In most cases, articles should progress to dealing with contemporary matters, not giving only historical material. The articles that are received the best by readers tend to relate different areas of mathematics to each other.

By design the *Notices* is partly magazine and partly journal, and authors' expository styles should take this into account. For example, many readers want to understand the mathematics articles without undue effort and without consulting other sources.

Mathematics feature articles in the *Notices* are normally six to nine pages, sometimes a little longer. Shorter articles are more likely to be read fully than are longer articles. The first page is 400 or 500 words, and subsequent pages are about 800 words. From this one should subtract an allowance for figures, photos, and other illustrations, and an appropriate allowance for any displayed equations and any bibliography.

Form of articles. Except with very short articles, authors are encouraged to use section headings and subsection headings to help orient readers. Normally there is no section heading at the beginning of an article. Despite the encouraged use of internal headings, the assigning of numbers to sections and subsections is not permitted in any article.

The bibliography should be kept short. In the case of mathematics articles, bibliographies are normally limited to about ten items and should consist primarily of entries like books in which one may do further reading. To help readers who might want lists of recent literature, an author might include a small number of recent publications with good bibliographies.

Editing process. Most articles that are destined to be accepted undergo an intensive editing process. The purposes of this process are to ensure that the target audience is as large as practicable, that the content of the article is clear and unambiguous, and that the article is relatively easy to read. Usually it is the members of the editorial board who are involved in this process. Sometimes outside referees are consulted.

Preparation of articles for submission. The preferred form for submitted articles is as electronic files. Authors who cannot send articles electronically may send the articles by fax or by postal mail.

Articles with a significant number of mathematical symbols are best prepared in TeX, LaTeX, or $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TeX. There are no special style files for the *Notices*, because TeX code gets converted to something else during the production process. Since the *Notices* is set in narrow columns, keeping displayed formulas relatively short helps to minimize adjustments during the production process; avoiding nonstandard supplementary files and complex sequences of TeX definitions also helps. For the handling of figures and other illustrations, please consult the editor.

Articles without a significant number of mathematical symbols may be prepared as text files or in Microsoft Word. In the case of files prepared in Microsoft Word, it is advisable to send both the file and a fax of a printout.

Instructions for Authors of "WHAT IS...?" Columns

The purpose of the "WHAT IS...?" column is to provide brief, nontechnical descriptions of mathematical objects in use in current research. The target audience for the columns is first-year graduate students.

Each "WHAT IS...?" column provides an expository description of a single mathematical object being used in contemporary research. Thus "WHAT IS M-Theory?" would be too broad, but "WHAT IS a Brane?" would be appropriate; ideally, "WHAT IS a Brane?" would give a flavor of what M-theory is.

The writing should be nontechnical and informal. The level should be a little higher than the level of popular articles about mathematical developments one finds in magazines like *Science* that are aimed at a general audience.

There is a strict limit of two *Notices* pages (1,400 words with no picture, or 1,200 words with one picture). A list of "Further Reading" should contain no more than three references.

Inquiries and comments about the "WHAT IS...?" column are welcome and may be sent to `notices-whatis@ams.org`.

Upcoming Deadlines

June 30, 2004: Full proposals for Joint DMS/BIO/NIGMS Initiative to Support Research in the Area of Mathematical Biology. See "Mathematics Opportunities" in this issue.

June 30, 2004: Proposals for DMS/NIGMS Program in Mathematical Biology. See `http://www.nsf.gov/pubs/2002/nsf02125/nsf02125.htm`.

July 22, 2004: Proposals for NSF CAREER Program. See "Mathematics Opportunities" in this issue.

August 1, 2004: Nominations for Clay Senior Scholars Program. See "Mathematics Opportunities" in this issue.

August 1, 2004: Applications for National Research Council Research Associateships. See `http://www4.nationalacademies.org/pga/rap.nsf`, or contact Research Associateship Programs, Keck Center of the National Academies, 500 Fifth Street, NW, GR322A, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: `rap@nas.edu`.

September 15, 2004: Nominations for Alfred P. Sloan Foundation fellowships. See "Mathematics Opportunities" in this issue.

September 16, 2004: Proposals for NSF Enhancing the Mathematical Sciences Workforce in the Twenty-First Century program (including VIGRE). See the website `http://www.nsf.gov/pubs/2003/nsf03575/nsf03575.htm`.

September 30, 2004: Nominations for Information-Based Complexity Young Researcher Award. Contact Joseph F. Traub at `traub@cs.columbia.edu`.

October 1, 2004: Nominations for the Louise Hay Award and the Alice T. Schafer Mathematics Prize. See "Mathematics Opportunities" in this issue.

October 1, 2004: Nominations for CRM-Fields Prize. See `http://www.fields.utoronto.ca/proposals/crm-fields_prize.html`, or contact the Director, The Fields Institute, 222 College Street, Toronto, Ontario M5T 3J1, Canada.

October 15, 2004: Applications for NSF Postdoctoral Research Fellowships. See `http://www.nsf.gov/pubs/2001/nsf01126/nsf01126.htm`.

January 1, 2005: Entries for *Cryptologia* undergraduate paper competitions. See `http://www.dean.usma.edu/math/pubs/cryptologia/` or contact *Cryptologia,* Department of Mathematical Sciences, United States Military Academy, West Point, NY 10996; email `Cryptologia@ usma.edu`.

New Journals for 2003

Below is a list of mathematical journals appearing for the first time in 2003, as compiled by *Mathematical Reviews.* This list, as well as the listings for new journals for other years, can be found on the Web at `http://www.ams.org/mathweb/mi-newjs.html`.

Analysis and Applications, 0219-5305, World Scientific Publishing, $240/4 issues/yr.

Applied Mathematics Research eXpress, 1687-1200, Hindawi Publishing Corp., $195/8+ issues/yr.

Archives of Inequalities and Applications, 1542-6149, Dynamic Publishers, Atlanta, $300/4 issues/yr.

Australasian Journal of Logic, 1448-5052, Philosophy Department, University of Melbourne, Parkville, free of charge.

Central European Journal of Mathematics, 1644-3616, Central European Science Journals, Warsaw, $670/4 issues/yr.

Communications in Mathematical Sciences, International Press, $195/yr.

Journal of Function Spaces and Applications, 0972-6802, Scientific Horizon, Delhi, $120/3 issues/yr.

Mathematica Macedonia, St. Cyril Methodius Univ., Skopje, price not listed, 1 vol./yr.

Multiscale Modeling and Simulation, 1540-3459, Society for Industrial and Applied Mathematics, $300/4 issues/yr.

Thai Journal of Mathematics, 1686-0209, Mathematical Assoc. of Thailand, price not listed, 2 issues/yr.

Book List

The Book List highlights books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. When a book has been reviewed in the Notices, *a reference is given to the review. Generally the list will contain only books published within the last two years, though exceptions may be made in cases where current events (e.g., the death of a prominent mathematician, coverage of a certain piece of mathematics in the news) warrant drawing readers' attention to older books. Suggestions for books to include on the list may be sent to* `notices-booklist@ams.org`.

*Added to "Book List" since the list's last appearance.

Abel's Proof: An Essay on the Sources and Meaning of Mathematical Unsolvability, by Peter Pesic. MIT Press, May 2003. ISBN 0-262-16216-4. (Reviewed March 2004.)

* *Across the Board: The Mathematics of Chessboard Problems,* by John J. Watkins. Princeton University Press, April 2004. ISBN 0-691-11503-6.

* *Adam Spencer's Book of Numbers,* by Adam Spencer. Four Walls Eight Windows, January 2004. ISBN 1-568-58289-7.

After Math, by Miriam Webster. Zinka Press, June 1997. ISBN 0-9647-1711-5. (Reviewed October 2003.)

Alan Turing: Life and Legacy of a Great Thinker, edited by Christof Teuscher. Springer, 2004. ISBN 3-540-20020-7.

* *Alpha & Omega: The Search for the Beginning and End of the Universe,* by Charles Seife. Viking, July 2003. ISBN 0-670-03179-8.

* *Automated Reasoning and the Discovery of Missing and Elegant Proofs,* by Larry Wos and Gail Pieper. Rinton Press, December 2003. ISBN 1-58949-023-1.

Beyond the Limit: The Dream of Sofya Kovalevskaya, by Joan Spicci. Forge, August 2002. ISBN 0-765-30233-0. (Reviewed January 2004.)

The Book of My Life, by Girolamo Cardano. New York Review of Books Classics Series/Granta. ISBN 1-590-17016-4.

Calculated Risks: How to Know When Numbers Deceive You, by Gerd Gigerenzer. Simon & Schuster, March 2003. ISBN 0-743-25423-6.

California Dreaming: Reforming Mathematics Education, by Suzanne M. Wilson. Yale University Press, January 2003. ISBN 0-300-09432-9. (Reviewed November 2003.)

The Changing Shape of Geometry: Celebrating a Century of Geometry and Geometry Teaching, edited by Chris Pritchard. Cambridge University Press, January 2003. ISBN 0-521-53162-4.

Codebreakers: Arne Beurling and the Swedish Crypto Program during World War II, by Bengt Beckman, translated by Kjell-Ove Widman. AMS, February 2003. ISBN 0-8218-2889-4. (Reviewed September 2003.)

The Constants of Nature: From Alpha to Omega—the Numbers That Encode the Deepest Secrets of the Universe, by John D. Barrow. Jonathan Cape, September 2002. Pantheon Books, January 2003. ISBN 0-375-42221-8.

Corréspondance Grothendieck-Serre, Pierre Colmez and Jean-Pierre Serre, editors. Société Mathématique de France, 2001. ISBN 2-85629-104-X. (Reviewed October 2003.)

* *The Curious Life of Robert Hooke, the Man Who Measured London*, by Lisa Jardine. HarperCollins, February 2004. ISBN 0-060-53897-X.

Einstein's Clocks, Poincaré's Maps: Empires of Time, by Peter Galison. W. W. Norton & Company, August 2003. ISBN 0-393-02001-0.

Everything and More: A Compact History of Infinity, by David Foster Wallace. W. W. Norton, October 2003. ISBN 0-393-00338-8. (Reviewed in this issue.)

* *Fields Medalists' Lectures*, edited by Sir Michael Atiyah and Daniel Iagolnitzer. World Scientific, 2nd edition, December 2003. ISBN 9-812-38259-3.

Four Colors Suffice: How the Map Problem Was Solved, by Robin Wilson. Princeton University Press, March 2003. ISBN 0-691-11533-8. (Reviewed in February 2004.)

The Fractal Murders, by Mark Cohen. Mysterious Press, Warner Books, May 2004. ISBN 0-89296-799-4. (Reviewed October 2003.)

* *Galois' Theory of Algebraic Equations*, by Jean-Pierre Tignol. World Scientific Publishing. ISBN 981-02-4541-6.

Gamma: Exploring Euler's Constant, by Julian Havil. Princeton University Press, May 2003. ISBN 0-691-09983-9.

Geometrical Landscapes: The Voyages of Discovery and the Transformation of Mathematical Practice, by Amir R. Alexander. Stanford University Press, September 2002. ISBN 0-804-73260-4.

Geometry: Our Cultural Heritage, by Audun Holme. Springer, April 2002. ISBN 3-540-41949-7. (Reviewed May 2004.)

Gödel's Proof, by Ernest Nagel and James R. Newman. New York University Press, revised edition, February 2002. ISBN 0-8147-5816-9. (Reviewed March 2004.)

The Golden Ratio: The Story of Phi, the World's Most Astonishing Number, by Mario Livio. Broadway Books, October 2002. ISBN 0-767-90815-5.

* *A Handbook of Mathematical Discourse*, by Charles Wells. Infinity Publishing Company, 2003. ISBN 0-7414-1685-9.

How Economics Became a Mathematical Science, by E. Roy Weintraub. Duke University Press, June 2002. ISBN 0-822-32856-9.

Imagining Numbers (particularly the square root of minus fifteen), by Barry Mazur. Farrar, Straus and Giroux, February 2003. ISBN 0-374-17469-5. (Reviewed November 2003.)

Infinity: The Quest to Think the Unthinkable, by Brian Clegg. Carroll & Graf, December 2003. ISBN 0-786-71285-6.

Information: The New Language of Science, by Hans Christian von Baeyer. Weidenfeld & Nicolson, October 2003. ISBN 0-297-60725-1 (hardcover), 0-753-81782-9 (paperback).

Isaac Newton, by James Gleick. Pantheon Books, May 2003. ISBN 0-375-42233-1. (Reviewed December 2003.)

Kepler's Conjecture: How Some of the Greatest Minds in History Helped Solve One of the Oldest Math Problems in the World, by George G. Szpiro. John Wiley & Sons, January 2003. ISBN 0-471-08601-0.

Linked: The New Science of Networks, by Albert-László Barabási. Perseus Publishing, May 2002. ISBN 0-738-20667-9. (Reviewed February 2004.)

Math through the Ages: A Gentle History for Teachers and Others, by William P. Berlinghoff and Fernando Q. Gouvêa. Oxton House, 2002. ISBN 1-881929-21-3.

Mathematical Constants, by Steven R. Finch. Cambridge University Press, August 2003. ISBN 0-521-81805-2.

* *Mathematical Journeys*, by Peter D. Schumer. Wiley-Interscience, February 2004. ISBN 0-471-22066-3.

A Mathematician's Survival Guide: Graduate School and Early Career Development, by Steven G. Krantz. AMS, August 2003. ISBN 0-821-83455-X. (Reviewed April 2004.)

Mathematicians under the Nazis, by Sanford L. Segal. Princeton University Press, July 2003. ISBN 0-691-00451-X.

Mathematics and Culture I, edited by Michele Emmer. Springer, January 2004. ISBN 3-540-01770-4.

Mathematics and the Roots of Postmodern Thought, by Vladimir Tasić. Oxford University Press, 2001. ISBN 0-195-13967-4. (Reviewed August 2003.)

* *Mathematics and War*, by Bernhelm Booss-Bavnbek and Jens Høyrup, editors. Birkhäuser, December 2003. ISBN 3-764-31634-9.

Mathematics, Art, Technology, and Cinema, edited by Michele Emmer and Mirella Manaresi. Springer, 2003. ISBN 3-540-00601-X.

Mathematics by Experiment: Plausible Reasoning in the 21st Century, by David Bailey, Jonathan Borwein. A K Peters, September 2003. ISBN 1-568-81136-5.

Mathematics for the Imagination, by Peter M. Higgins. Oxford University Press, November 2002. ISBN 0-198-60460-2.

* *Mathematics in Nature: Modeling Patterns in the Natural World*, by John Adam. Princeton University Press, November 2003. ISBN 0-691-11429-3.

The Mathematics of Juggling, by Burkard Polster. Springer, November 2002. ISBN 0-387-95513-5. (Reviewed January 2004.)

Memoirs of a Proof Theorist: Gödel and Other Logicians, by Gaisi Takeuti. Translated by Mariko Yasugi and Nicholas Passell. World Scientific, February 2003. ISBN 981-238-279-8.

* *Meta Math! The Quest for Omega*, by Gregory J. Chaitin. April 2004. Available at `http://www.cs.umaine.edu/~chaitin/omega.html`.

The Millennium Problems: The Seven Greatest Unsolved Mathematical Puzzles of Our Time, by Keith J. Devlin. Basic Books, October 2002. ISBN 0-465-01729-0. (Reviewed September 2003.)

More Mathematical Astronomy Morsels, by Jean Meeus. Willmann-Bell Inc., 2002. ISBN 0-943396-743.

The Music of the Primes: Searching to Solve the Greatest Mystery in Mathematics, by Marcus Du Sautoy. HarperCollins, April 2003. ISBN 0-066-21070-4.

Newton's Apple: Isaac Newton and the English Scientific Renaissance, by Peter Aughton. Weidenfeld & Nicolson, October 2003. ISBN 0-297-84321-4.

The Number π, by Pierre Eymard and Jean-Pierre Lafon. AMS, 2004. ISBN 0-8218-3246-8.

On the Nature of Human Romantic Interaction, by Karl Iagnemma. Dial Press, April 2003. ISBN 0-385-33593-8.

Computation Sciences & Mathematics

Senior Research Scientist I, Level 3

Senior Research Scientist II, Level 4

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Fundamental Science Directorate, Statistical & Mathematics Sciences

Description: The Statistical & Mathematical Sciences group at the Pacific Northwest National Laboratory (PNNL) seeks an applied statistician or mathematician with a strong background in physical and/or nuclear science. Competency in mathematical statistics and multivariate analysis is required. Proficiency in one or more of the following is highly desired: signal processing, pattern recognition, discrimination, Bayesian theory, or applied stochastic modeling. Experience in the analysis of high dimensional data in spectral and spatial domains will be a differentiator in employment consideration. The successful candidate will have strong education/experience in general physics or nuclear science, and be actively developing a national reputation. Scientific staff at PNNL have the opportunity to work on projects related to national security and homeland security with opportunities in original research and publication related to these business sectors. Providing technical leadership to a team of staff, professional activity through publication, writing successful proposals, and congenial client/staff interactions is expected. Successful technical staff at PNNL quickly demonstrate an ability to manage the technical scope and work of fairly large projects, and develop business in a targeted national mission/program – they are excellent mentors and talented technical communicators.

Minimum Requirements:†

Level III: MS plus 3+ years relevant experience or PhD plus 1+ years relevant experience preferred in mathematical statistics applied to general physics or nuclear science (or other related fields)

Level IV: MS 7+ years relevant experience, or PhD plus 4+ years relevant experience in mathematical statistics applied to general physics or nuclear science (or other related fields)

The ability to obtain and maintain a DOE security clearance is required. The ability to meet contractor requirements for the Department of Homeland Security is required.

Note: †Must meet minimum requirements to receive further consideration.

Placement level will be dependent upon management's assessment of the selected candidate's skills, experience, and ability to contribute. In order to reduce cycle time, internal and external solicitations of interest may run concurrent, however, qualified PNNL staff will be given first consideration.

About PNNL: "PNNL will be recognized worldwide and valued regionally for our leadership in integrating chemical, physical, and biological sciences to rapidly translate discoveries into solutions for challenges in energy, national security, and the environment." Dr. Len Peters, Laboratory Director.

To Apply: Visit our website at http://jobs.pnl.gov and submit to reference number **107179**

PNNL is an EEO/AA employer and values diversity in the workplace. F/M/D/V are encouraged to apply.

Reference and Book List

The One True Platonic Heaven: A Scientific Fiction of the Limits of Knowledge, by John L. Casti. Joseph Henry Press, May 2003. ISBN 0-309-08547-0.

Portraits of the Earth: A Mathematician Looks at Maps, by Timothy G. Freeman. AMS, September 2002. ISBN 0-8218-3255-7.

Predicting Presidential Elections and Other Things, by Ray C. Fair. Stanford University Press, August 2002. ISBN 0-804-74509-9.

Prime Obsession: Bernhard Riemann and the Greatest Unsolved Problem, by John Derbyshire. Joseph Henry Press, March 2003. ISBN 0-309-08549-7.

Proofs from the Book, by Martin Aigner and Günter M. Ziegler. Springer Verlag, third edition, December 2003. ISBN 3-540-40460-0.

The Riemann Hypothesis: The Greatest Unsolved Problem in Mathematics, by Karl Sabbagh. Farrar Straus & Giroux, April 2003. ISBN 0-374-25007-3.

The Saga of Mathematics: A Brief History, by Marty Lewinter and William Widulski. Prentice Hall, January 2002. ISBN 0-130-34079-0.

Science in the Looking Glass, by E. Brian Davies. Oxford University Press, August 2003. ISBN 0-19-852543-5.

The Search for Certainty: A Philosophical Account of Foundations of Mathematics, by Marcus Giaquinto. Oxford University Press, October 2002. ISBN 0-198-75244-X.

Shooting the Sun, by Max Byrd. Bantam, December 2003. ISBN 0-553-80208-9.

Six Degrees: The Science of a Connected Age, by Duncan J. Watts. W. W. Norton & Company, February 2003. ISBN 0-393-04142-5. (Reviewed February 2004.)

Strange Curves, Counting Rabbits, and Other Mathematical Explorations, by Keith Ball. Princeton University Press, November 2003. ISBN 0-691-11321-1.

Sync: The Emerging Science of Spontaneous Order, by Steven Strogatz. Hyperion, February 2003. ISBN 0-786-86844-9. (Reviewed March 2004.)

Travels in Four Dimensions: The Enigmas of Space and Time, by Robin Le Poidevin. Oxford University Press, February 2003. ISBN 0-19-875254-7.

What Is Thought?, by Eric B. Baum. MIT Press, January 2004. ISBN 0-262-02548-5.

What the Numbers Say: A Field Guide to Mastering Our Numerical World, by Derrick Niederman and David Boyum. Broadway Books, April 2003. ISBN 0-767-90998-4.

* *When Least Is Best: How Mathematicians Discovered Many Clever Ways to Make Things As Small (or As Large) As Possible*, by Paul J. Nahin. Princeton University Press, November 2003. ISBN 0-691-07078-4.

From the AMS Secretary

Ethical Guidelines for the Society

In January 1994 the Council received the report of its Special Advisory Committee on Professional Ethics. The committee, which consisted of Murray Gerstenhaber, Frank Gilfeather, Elliott Lieb, and Linda Keen (chair), presented ethical guidelines for adoption by the Council. Those draft guidelines were published twice in the *Notices*, with a request to the membership for responses and suggestions for changes or improvements. These were sent to the committee, which considered all suggestions. The committee then redrafted the guidelines, which were presented to the January 1995 Council. At that meeting, the Council voted to adopt these guidelines on behalf of the Council (by a vote that was unanimous save for one abstention). Acting upon recommendations from the AMS Committee on the Profession, in January 2004 the Council approved a general revision to the document, which also incorporated additional statements describing and deploring plagiarism.

Ethical Guidelines of the American Mathematical Society

To assist in its chartered goal, "the furtherance of the interests of mathematical scholarship and research", and to help in the preservation of that atmosphere of mutual trust and ethical behavior required for science to prosper, the Council of the American Mathematical Society sets forth the following ethical guidelines. These guidelines reflect its expectations of behavior both for AMS members as well as for all individuals and institutions in the wider mathematical community, including those engaged in the education or employment of mathematicians or in the publication of mathematics.

These guidelines are not a complete expression of the principles that underlie them. The guidelines are not meant to be a complete list of all ethical issues. They will be modified and amplified by events and experience. These are guidelines, not a collection of rigid rules.

The American Mathematical Society, through its Committee on Professional Ethics (COPE), may provide an avenue of redress for individual members injured in their capacity as mathematicians by violations of these ethical principles. In each case, COPE will determine the appropriate ways in which it can be helpful (including making recommendations to the Council of the Society). The AMS cannot enforce these guidelines, however, and it cannot substitute for individual responsibility or for the responsibility of the mathematical community at large.

I. Mathematical Research and Its Presentation

The public reputation for honesty and integrity of the mathematical community and of the Society is its collective treasure and its publication record is its legacy.

The knowing presentation of another person's mathematical discovery as one's own constitutes plagiarism and is a serious violation of professional ethics. Plagiarism may occur for any type of work, whether written or oral and whether published or not.

The correct attribution of mathematical results is essential, both because it encourages creativity by benefitting the creator whose career may depend on the recognition of the work and because it informs the community of when, where, and sometimes how original ideas entered into the chain of mathematical thought. To that end, mathematicians have certain responsibilities, which include the following:

—To endeavor to be knowledgeable in their field, especially about work related to their research;

—To give appropriate credit, even to unpublished materials and announced results (because the knowledge that something is true or false is valuable, however it is obtained);

—To use no language that suppresses or improperly detracts from the work of others;

—To correct in a timely way or to withdraw work that is erroneous.

A claim of independence may not be based on ignorance of widely disseminated results. On appropriate occasions, it may be desirable to offer or accept joint authorship when independent researchers find that they have produced identical results. All the authors listed for a paper, however, must have made a significant contribution to its content, and all who have made such a contribution must be offered the opportunity to be listed as an author. Because the free exchange of ideas necessary to promote research is possible only when every individual's contribution is properly recognized, the Society will not knowingly publish anything that violates this principle, and it will seek to expose egregious violations anywhere in the mathematical community.

To claim a result in advance of its having been achieved with reasonable certainty injures the community by restraining those working toward the same goal. Publication of the full details of results that are announced must not be unreasonably delayed.

II. Social Responsibility of Mathematicians

The Society promotes mathematical research together with its unrestricted dissemination, and to that end encourages all to engage in this endeavor. Mathematical ability must be respected wherever it is found, without regard to race, gender, ethnicity, age, sexual orientation, religious belief, political belief, or disability.

The growing importance of mathematics in society at large and of public funding of mathematics may increasingly place members of the mathematical community in conflicts of interest. The appearance of bias in reviewing, refereeing, or in funding decisions must be scrupulously avoided, particularly where decisions may affect one's own research, that of colleagues, or of one's students. When conflicts of interest occur, one should withdraw from the decision-making process.

A recommendation accurately reflecting the writer's views is often given only on the understanding that it be kept confidential; therefore, a request for a recommendation must be assumed to carry an implicit promise of confidentiality, unless there is a statement to the contrary. Similarly, a referee's report is normally provided with the understanding that the name of the writer be withheld from certain interested parties, and the referee must be anonymous unless otherwise indicated in advance. The writer of the recommendation or report must respond fairly and keep confidential any privileged information, personal or mathematical, that the writer receives. If the requesting individual, institution, agency or company becomes aware that confidentiality or anonymity cannot be maintained, that should be immediately communicated.

Where choices must be made and conflicts are unavoidable, as with editors or those who decide on appointments or promotions, it is essential to keep careful records that would demonstrate the process was indeed fair when inspected at a later time.

Freedom to publish must sometimes yield to security concerns, but mathematicians should resist excessive secrecy demands whether by government or private institutions.

When mathematical work may affect the public health, safety or general welfare, it is the responsibility of mathematicians to disclose the implications of their work to their employers and to the public, if necessary. Should this bring retaliation, the Society will examine the ways in which it may want to help the "whistle-blower", particularly when the disclosure has been made to the Society.

No one should be exploited by the offer of a temporary position at an unreasonably low salary and/or an unreasonably heavy workload.

III. Education and Granting of Degrees

Holding a Ph.D. degree is virtually indispensable to an academic career in mathematics and is becoming increasingly important as a certificate of competence in the wider job market. An institution granting a degree in mathematics is certifying that competence and must take full responsibility for it by insuring the high level and originality of the Ph.D. dissertation work, and sufficient knowledge by the recipient of important branches of mathematics outside the scope of the thesis. When there is evidence of plagiarism it must be carefully investigated, even if it comes to light after granting the degree, and, if proven, the degree should be revoked.

Mathematicians and organizations involved in advising graduate students should fully inform them about the employment prospects they may face upon completion of their degrees.

IV. Publications

Editors are responsible for the timely refereeing of articles and must judge articles by the state of knowledge at the time of submission. Editors should accept a paper for publication only if they are reasonably certain the paper is correct.

The contents of a submitted manuscript should be regarded by a journal as privileged information. If the contents of a paper become known in advance of publication solely as a result of its submission to or handling by a journal, and if a later paper based on knowledge of the privileged information is received anywhere (by the same or another journal), then any editor aware of the facts must refuse or delay publication of the later paper until after publication of the first—unless the first author agrees to earlier publication of the later paper.

At the time a manuscript is submitted, editors should notify authors whenever a large backlog of accepted papers may produce inordinate delay in publication. A journal may not delay publication of a paper for reasons of an editor's self-interest or of any interest other than the author's. The published article should bear the date on which the manuscript was originally submitted to the journal for publication, together with the dates of any revisions. Editors must be given and accept full scientific responsibility for their journals; when a demand is made by an outside agency for prior review or censorship of articles, that demand must be resisted and, in any event, knowledge of the demand must be made public.

Both editors and referees must respect the confidentiality of materials submitted to them unless these materials have previously been made public, and above all may not appropriate to themselves ideas in work submitted to them or do anything that would impair the rights of authors to the fruits of their labors. Editors must preserve the anonymity of referees unless there is a credible allegation of misuse.

All mathematical publishers, particularly those who draw without charge on the resources of the mathematical community through the use of unpaid editors and referees, must recognize that they have made a compact with the community to disseminate information, and that compact must be weighed in their business decisions.

The Society will not take part in the publishing, printing or promoting of any research journal where there is some acceptance criterion, stated or unstated, that conflicts with the principles of these guidelines. It will promote the quick refereeing and timely publication of articles accepted to its journals.

—As adopted by the Council of the American Mathematical Society on January 6, 2004.

Mathematics Calendar

The most comprehensive and up-to-date Mathematics Calendar information is available on e-MATH at `http://www.ams.org/mathcal/`.

June 2004

2004 **Fifth Edition of the International Conference on Functional Analysis and Approximation Theory**, Acquafredda di Maratea, Potenza, Italy. (Feb. 2004, p. 278)

2004 **Mathematical Foundations of Learning Theory**, Barcelona, Spain. (Apr. 2003, p. 499)

2004 **WSEAS Conferences**, Corfu Island, Greece. (Apr. 2003, p. 500)

1-4 **Galois Theory and Arithmetic (GATA 2004)**, Mathematisches Institut der Universität Bonn, Bonn, Germany. (May 2004, p. 574)

1-4 **International Workshop on Nonlinear Waves**, The Chinese University of Hong Kong, Hong Kong. (Dec. 2003, p. 1440)

1-5 **Asymptotic Theories and Painlevé Equations**, Université d'Angers, France. (May 2004, p. 574)

*1-7 **Logic, Algebra and Geometry: A meeting in the Methods of Logic in Mathematics Series**, Euler Mathematical Institute, St. Petersburg, Russia.
Purpose: To discuss the interaction between logic and other branches of mathematics, e.g., algebra and geometry. The meeting will consist of Invited Talks, Tutorials and sessions for Contributed Papers.
Tutorials: A. Vershik (St. Petersburg Department of Steklov Institute) and O. Lessmann (Oxford) and Su Gao (North Texas). Abstracts of contributed talks should be sent to email: `meeting@logic.pdmi.ras.ru`.
Invited Speakers: J. Baldwin (Illinois), A. Blass (Ann Arbor, Michigan), J. Brendle (Kobe), P. Cameron (London, QMC), Yu. Ershov (Novosibirsk), M. Foreman (Univ. Calif., Irvine), M. Forti (Pisa), Su Gao (North Texas), M. Gavrilovich (Oxford), E. Gordon (Eastern Illinois), G. Hjorth (UCLA), T. Hyttinen (Helsinki), O. Lessmann (Oxford), M. di Nasso (Pisa), O. Spinas (Kiel), J. Steprans (Toronto), S. Thomas (Rutgers), S. Todorcevic (Paris 7, Toronto, Belgrade), V. Tolstykh (Kemerovo), B. Velickovic (Paris 7), A. Vershik (St. Petersburg Department of Steklov Institute) and Yi Zhang (Sun Yat-sen, Guangzhou).
Program Committee: M. Arslanov (Kazan), A. Blass (Michigan, Ann Arbor), A. Bovykin (Steklov Institute, St.Petersburg), E. Griffor (CAI/Michigan, Ann Arbor), A. Kechris (CalTech), J. Steprans (Toronto), Su Gao (North Texas), A. Vershik, co-chair (Steklov Institute, St.Petersburg), Yu.Ershov (Novosibirsk), Yi Zhang, co-chair (Sun Yat-sen, Guangzhou), B. Zilber (Oxford).
Local Organizing Committee: Anatoly Vershik, Yi Zhang, Elena Novikova and Andrey Bovykin.
Contact: Elena Novikova; email: `novikova@pdmi.ras.ru`.
Information: Registration can be done online at `http://www.pdmi.ras.ru/EIMI/2004/lag/app.html`; `http://www.math.lsa.umich.edu/logicmethods`.

1-11 **Workshop on Semi-classical Theory of Eigenfunctions and PDEs**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 848)

2-4 **ICNPAA 2004: Mathematical Problems in Engineering and Aerospace Sciences**, The West University of Timisoara, Romania. (May 2003, p. 604)

*2-5 **DIMACS Working Group on Computer-Generated Conjectures from Graph Theoretic and Chemical Databases II**, HEC Montreal 3000, Montreal, Quebec, Canada.
Short Description: Computers are increasingly used in mathematics and the sciences. To the traditional number-crunching have been

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This section contains announcements of meetings and conferences of interest to some segment of the mathematical public, including ad hoc, local, or regional meetings, and meetings and symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. A complete list of meetings of the Society can be found on the last page of each issue.

An announcement will be published in the *Notices* if it contains a call for papers and specifies the place, date, subject (when applicable), and the speakers; a second announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in every third issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared. Asterisks (*) mark those announcements containing new or revised information.

In general, announcements of meetings and conferences held in North America carry only the date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. Meetings held outside the North American area may carry more detailed information. In any case, if there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the *Notices* in care of the American Mathematical Society in Providence or electronically to `notices@ams.org` or `mathcal@ams.org`.

In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence **eight months** prior to the scheduled date of the meeting.

The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.

The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through the AMS website on the World Wide Web. To access the AMS website, use the URL: `http://www.ams.org/`.

added formal methods, automated proof techniques, and recently a large number of approaches to computer-aided automated discovery. The resulting techniques in this last endeavor are grouped under various names: experimental mathematics, discovery science, data mining and knowledge discovery, and the like. They are based on many different principles such as integer relation finding inductive logic programming or the joint use of metaheuristics and data analysis methods. They have led to strong results in many fields. Some of these results are very surprising, e.g. the discovery by Bailey Borwein and Plouffe of a relation for p which allows finding the value of any bit of its binary expansion without knowing the previous ones.
Sponsors: DIMACS and GERAD: Group for Research in Decision Analysis.
Organizers: Patrick Fowler, University of Exeter, `P.W.Fowler@exeter.ac.uk`; Pierre Hansen, GERAD—École des Hautes Études Commerciales, email: `Pierre.Hansen@gerad.ca`.
Aims: The workshop will have several aims: (i) To survey main results obtained in computer-aided or automated discovery in various fields of mathematics, such as number theory, geometry, graph theory, algebra, etc., as well as in various sciences such as chemistry, physics, bioinformatics, economics, ecology, etc.; (ii) to present and discuss main tools of computer-aided or automated discovery; (iii) to illustrate the working of software for discovery through demonstrations and discussions; (iv) to stimulate the initiation of collaborative research between teams using different techniques and/or working in different fields.
Information: `http://dimacs.rutgers.edu/Workshops/Conjectures2/`. Please contact the organizers or Carole Dufour at GERAD (`Carole.Dufour@gerad.ca`).

3-10 **Sixth International Conference on Geometry, Integrability and Quantization**, Sts. Constantine and Elena Resort (near Varna), Bulgaria. (Mar. 2004, p. 357)

3-25 **MRI Spring School 2004: Lie Groups in Analysis, Geometry and Physics**, Utrecht University, Utrecht, The Netherlands. (Jan. 2004, p. 62)

5-26 **Clay Mathematics Institute Summer School: Floer Homology, Gauge Theory, and Low Dimensional Topology**, Alfréd Rényi Institute of Mathematics, Budapest, Hungary. (Apr. 2004, p. 457)

6-10 **Joint Summer Research Conference: String Geometry**, Snowbird Resort, Snowbird, Utah. (Feb. 2004, p. 278)

*6-11 **Gordon Research Conference on Theoretical Biology & Biomathematics**, Tilton School, Tilton, New Hampshire.
Chairs: T. Elston & R. Mejia.
Vice Chair: P. Bressloff.
Information:`http://www.grc.uri.edu/programs/2004/theobio.htm`.

*7-9 **DIMACS Workshop on Security Analysis of Protocols**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Sponsors: DIMACS and PORTIA.
Topics: Analysis methods involving computational complexity, game-theoretic approaches, methods based on logic and symbolic computation, probabilistic methods, model checking and symbolic search, formal proof systems, decision procedures and lower bounds, anything else that sounds like a great idea .
Organizers: J. Mitchell, Stanford, email: `mitchell@cs.stanford.edu`; R. Canetti, IBM Watson, email: `canetti@watson.ibm.com`.
Local Arrangements: M. Mercado, DIMACS Center, email: `mercado@dimacs.rutgers.edu`, 732-445-5928.
Deadlines: Registration: May 28, 2004.
Information: `http://dimacs.rutgers.edu/Workshops/Protocols/`.

7-10 **SEM 10th International Congress and Exposition on Experimental Mechanics**, Hilton Costa Mesa, Costa Mesa, California. (May 2004, p. 574)

7-10 **Sixth International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing and Second International Conference on Monte Carlo and Probabilistic Methods for Partial Differential Equations**, Juan-les-Pins, France. (Dec. 2003, p. 1440)

7-10 **Symposium on Analysis and PDEs**, Purdue University, West Lafayette, Indiana. (Mar. 2004, p. 357)

7-11 **4th Conference on Poisson Geometry**, University of Luxembourg, Luxembourg City, Grand-Duchy of Luxembourg. (Dec. 2003, p. 1441)

7-11 **Computational and Statistical Aspects of Microarray Analysis**, Bressanone, Italy. (Apr. 2004, p. 457)

*7-11 **Fourth International Conference on Mathematics & Design**, Mar del Plata, Buenos Aires, Argentina.
Organizers: Vera Martha Winitzky de Spinadel, president, International Mathematics & Design Association; Carlos Eduardo Fantini, vice-rector, Universidad Tecnológica Nacional, Argentina.
Information: `http://www.myd2004.org.ar`.

*7-11 **The Combinatorics of Large Sparse Graphs**, Cal State San Marcos, San Marcos, California.
Sponsors: NSF, CBMS.
Featured Speaker: Ten lectures by F. C. Graham.
Organizers: R. Ramamurthi; A. Kundgen.
Information: `http://www.csusm.edu/Math/CBMS/`.

7-26 **Probability Models and Statistical Analyses for Ranking Data**, University of Ottawa, Ontario, Canada. (Apr. 2004, p. 457)

8-9 **DIMACS Workshop on Genomic Instability in Cancer: Biological and Mathematical Approaches**, Institute for Advanced Study, Princeton, New Jersey. (Apr. 2004, p. 457)

8-13 **Representation Theory, Dynamical Systems, and Asymptotic Combinatorics**, St. Petersburg, Russia. (May 2004, p. 574)

9-12 **Call for Papers/Abstracts/Submissions: Hawaii International Conference on Statistics, Mathematics and Related Fields**, Sheraton Waikiki Hotel, Honolulu, Hawaii. (Dec. 2003, p. 1441)

10-12 **Lehigh University Geometry/Topology Conference**, Lehigh University, Bethlehem, Pennsylvania. (May 2004, p. 574)

*11-12 **Seminar Sophus Lie**, Université de Metz, Metz, France.
Invited Speakers: Jean Bellissard (Georgia Inst. of Tech.), Jean-Louis Clerc (Univ. de Nancy I), Jacques Faraut (Univ.. et Marie Curie, Paris 6), Thomas Friedrich (Humboldt Univ. Berlin), Peter Heinzner (Ruhr-Univ. Bochum), Victor Nistor (Penn State Univ.), Gestur Olafsson (Louisiana State Univ.), Tudor Ratiu (EPF Lausanne), Robert Wendt (Univ. of Toronto).
Information: `http://www.mmas.univ-metz.fr/~pasquale/SSL/SSL04.html`.

13-16 **SIAM Conference on Discrete Mathematics (DM04)**, Loews Vanderbilt Plaza Hotel, Nashville, Tennessee. (Oct. 2003, p. 1129)

13-17 **Joint Summer Research Conference: Complex Dynamics: Twenty-Five Years after the Appearance of the Mandelbrot Set**, Snowbird Resort, Snowbird, Utah. (Feb. 2004, p. 278)

13-18 **Algorithmic Number Theory Symposium VI (ANTS-VI)**, United States Naval Academy, Annapolis, Maryland. (Oct. 2003,p. 1129)

*13-18 **Emerging Applications of Measure Rigidity**, AIM Research Conference Center, Palo Alto, California.
Organizers: Anatole Katok, Elon Lindenstrauss, and Ralf Spatzier.
Topics: This workshop, sponsored by AIM and the NSF, will be devoted to exploring the interplay between flows on locally homogeneous spaces and a wide range of problems in number theory, theoretical physics, and representation theory. Specific topics include: classification of measures invariant under natural

flows on locally homogeneous spaces, particularly Cartan-type actions, unipotent flows and their applications to Diophantine approximations, L-functions, Heegner points, quantum chaos, and many other major areas of vigorous mathematical research.
Information: `http://aimath.org/ARCC/workshops/measrigid.html`.

14-18 (REVISED) **Conference on Surface Water Waves**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 457)

15-17 **DIMACS Workshop on Mobile and Wireless Security**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Apr. 2004, p. 457)

*16-18 **Vanderbilt University Conference-Mathematical Models in Signaling Systems**, Vanderbilt University, Nashville, Tennessee.
Description: This conference will bring together biologists, physicists, mathematicians and computational scientists, to assess the state of the art in quantitative modeling of signal transduction networks. The meeting will identify a set of methods and ideas and trace future directions for this emerging field. In addition, it will provide a reference forum for students and young scientists who are training to take interdisciplinary and systems approaches to signal transduction, pharmacology and cell biology.
Sponsor: Sponsored by Vanderbilt University, the National Academies Keck Futures Initiative, and AstraZeneca.
Topics: Detailed Local Models of Signaling Pathways, Cellular Models and Spatial Complexity, Experimental Approaches to Understanding Networks, Analysis of Network Architecture.
Information: Registration Scholarships now available. For more information, please visit `http://www.nationalacademies.org/keck`;`http://medschool.mc.vanderbilt.edu/math_conference/index.php`; phone: 615-322-0672.

16-19 **AIMS' Fifth International Conference on Dynamical Systems and Differential Equations**, California State Polytechnic University, Pomona, California. (Aug. 2003, p. 848)

*16-19 **First Advanced Course in Operator Theory and Complex Analysis**, Seville, Spain.
Description: Although classical, it is a remarkable fact that complex analysis and operator theory are providing an unending number of rich and new ideas in mathematics. One of the purposes of these advanced courses delivered by well-renowned researchers is to show that these two areas are still emerging with full strength.
Topics: The topics will vary from determining the conformal type of Riemann surfaces to concrete classical operators acting on classical spaces of analytic functions, passing through how the behaviour of the powers of the classical shift operator determines whether every function in a given space of analytic functions on the disk has nontangential limits almost everywhere and lattices of jointly invariant subspaces for two Fourier translation semigroups.
Speakers: Alexandru Aleman (Lund Univ.), Analytic Contractions and Nontangential Boundary Behavior; David Drasin (NSF, Purdue Univ.), How Big Is a Riemann Surface?; Stephen Power (Lancaster Univ., UK), Invariant Subspaces of Translation Semigroups; Aristomenis Siskakis (Aristotle Univ. of Thessaloniki, Greece), Operators of Integration on Spaces of Analytic Functions.
Information: `http://www.us.es/ceacyto/`.

16-23 **5th International Conference on Functional Analysis and Approximation Theory (FAAT 2004)**, Hotel Villa del Mare, Acquafredda di Maratea, Potenza, Italy. (Mar. 2004, p. 358)

17-18 **Analysis, Probability, and Logic: A Conference in Honor of Edward Nelson**, University of British Columbia, Vancouver, BC, Canada. (Apr. 2004, p. 457)

17-19 **Conference in Honour of Dale Brownawell**, University of Waterloo, Waterloo, Ontario, Canada. (Apr. 2004, p. 457)

18-20 **High Performance Software for Nonlinear Optimization: Status and Perspectives**, Ischia, Italy. (Feb. 2004, p. 278)

18-23 **Mathematical Foundations of Learning Theory**, Barcelona, Spain. (Dec. 2003, p. 1441)

19-24 **Symmetries and Integrability of Difference Equations—EuroConference on Analytic Difference Equations, Special Functions and Quantum Models on the Lattice**, Helsinki, Finland. (Apr. 2004, p. 458)

*19-26 **DIMACS Working Group on the Mathematics of Web Search and Meta-Search**, Bertinoro International Center for Informatics, Bertorino, Italy.
Short Description: In an election each of a large number k of voters ranks a small number n of candidates. The rankings are then combined in some fashion to elect either a single or several candidates. The formal analysis of voting began in France in the latter half of the eighteenth century with two seminal, but conflicting, approaches proposed respectively by Jean Charles de Borda and Marie J. A. N. Caritat, the Marquis de Condorcet. This laid the groundwork for an extensive literature on the mathematics of voting. Fast-forwarding to a more modern problem: In Web meta-search, in response to a given query, each of a small number k of search engines (voters) ranks a (subset of a) large number n of candidates (pages). The results are then combined in some fashion to produce a ranking that is in some sense "better" than the results produced by any single search engine. As phrased here, the connection between voting, analysis of rank data, and the mathematics of (Web) search and meta-search is patent. Indeed, the voting literature inspired several of the meta-search results.
Sponsor: DIMACS.
Organizers: Cynthia Dwork, Microsoft, email: `dwork@microsoft.com`; Andrew Gelman, Columbia University, email: `gelman@stat.columbia.edu`; D. Sivakumar, IBM Almaden, email: `siva@almaden`.
Information: `http://dimacs.rutgers.edu/Workshops/WGWebSearch/`.

20-25 **Canadian Number Theory Association VIII Meeting**, University of Toronto, Toronto, Ontario, Canada. (Dec. 2003, p. 1441)

20-25 **8th Symposium on Probability and Stochastic Processes**, Universidad de las Americas, Cholula, Puebla, Mexico. (Nov. 2003, p. 1314)

*20-26 **Reconnect Conference: Experimental Algorithmics, with a Focus on Branch and Bound for Discrete Optimization Problems**, Lafayette College, Easton, Pennsylvania.
Principal Speaker: C. Phillips, Sandia National Laboratories, email: `caphill@sandia.gov`.
Organizers: R. Leibowitz, Wheaton College (`rochelle_leibowitz@wheatonma.edu`); F. S. Roberts, Rutgers University (`froberts@dimacs.rutgers.edu`).
Information: `http://dimacs.rutgers.edu/reconnect/`. Contact: email: `reconnect@dimacs.rutgers.edu`, tel: 732-445-5928.

20-27 **42nd International Symposium on Functional Equations**, Opava, Czech Republic. (Jan. 2004, p. 62)

21-23 **V Italian-Spanish Conference on General Topology and Its Applications**, Almeria, Spain. (Mar. 2004, p. 358)

*21-24 **ICCASV—International Conference on Complex Analysis in Several Variables**, Mid Sweden University, Sundsvall, Sweden.
Scientific Committee: U. Cegrell, C. Kiselman, T. Oshawa.
Organizing Committee: F. Kutzschebauch, A. Fällström.
Speakers: (More speakers are to be added): A. Atsuji, Z. Blocki, A. Brudnyi, B. Y. Chen, J. D'Angelo, S. Fu, S. Kolodziej, A. Nicoara, M. Shaw, M. Zaidenberg.
Information: `http://www.fmi.mh.se/~plus/iccasv.html`.

21-25 **Conference in Nonlinear Analysis, in Honor of Haïm Brezis, on the Occasion of His 60th Birthday**, Paris, France. (Jan. 2004, p. 62)

*21-25 **BioMaPS/DIMACS/MBBC/PMMB Short Course: Transcriptional Regulation from Molecules to Systems and Beyond,** DIMACS Center, CoRE Building, Rutgers University, Piscataway, New Jersey.

Short Description: The second annual BioMaPS Summer School, organized by Rutgers University Professors Wilma Olson and Anirvan Sengupta, will feature the short course "Transcriptional Regulation from Molecules to Systems and Beyond."

Sponsor: BioMaPS Institute in collaboration with the Center for Discrete Mathematics and Theoretical Computer Science (DIMACS), the Center for Molecular Biophysics and Biophysical Chemistry (MBBC), and the Program in Mathematics and Molecular Biology (based at Florida State University). The Sloan Foundation and the Burroughs-Wellcome Fund provide partial funding of the BioMaPS Summer School. Additional information is posted on the BioMaPS Web site (at: http://www.biomaps.rutgers.edu/summer_school.htm) and the DIMACS Web site (at: http://dimacs.rutgers.edu/Workshops/Transcription/).

Organizers: Wilma Olson, Rutgers University, email: olson@rutchem.rutgers.edu. Anirvan Sengupta, Rutgers University, email: anirvan@physics.rutgers.edu.

Course Goals and Intended Audience: This short course on transcription is designed to: (1) enable participants with advanced training in the mathematical, computational, and physical sciences, but with a more limited background in biology, to contribute to research at the interface of the biological, mathematical, and physical sciences, (2) introduce participants with traditional backgrounds in biochemistry, genetics, and molecular biology to the potential value of quantitative approaches in their own work, and (3) provide participants with in-depth training in an important subfield within molecular biology. The course is appropriate for graduate students, post-doctoral fellows, faculty members, and biomedical researchers from non-academic organizations.

Information: http://dimacs.rutgers.edu/Workshops/Transcription/.A registration form, application for financial support, and information on accommodations and travel arrangements are posted on the DIMACS Web site.

21-25 **Conference on Surface Water Waves**, The Fields Institute, Toronto, Ontario, Canada. (Oct. 2003, p. 1129)

21-26 **Nonlinear Modelling and Control, an International Seminar**, Nayanova University, Samara, Russia. (Mar. 2004, p. 358)

21-July 2 **Artificial Neural Networks**, University of Wyoming, Laramie, Wyoming. (Feb. 2004, p. 278)

21-July 2 **SMS-NATO Advanced Summer Institute : Morse Theoretic Methods in Nonlinear Analysis and Symplectic Topology**, Université de Montréal, Québec, Canada. (Feb. 2004, p. 278)

*22-26 **Retrospective in Combinatorics: Honoring Richard Stanley's 60th Birthday**, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Information: http://www.math.ucsd.edu/~stanfest.

22-27 **Representation Theory and Its Applications**, Uppsala University, Uppsala, Sweden. (Mar. 2004, p. 358)

24-26 **Statistical Mechanics: A Conference in Honour of the 75th Birthday of Oliver Penrose**, ICMS, Edinburgh, United Kingdom. (Apr. 2004, p. 458)

26-July 1 **The Future of Mathematics Education**, Ciechocinek, Poland. (Jan. 2004, p. 63)

27-July 2 **2004 USENIX Annual Technical Conference**, Boston, Massachusetts. (Dec. 2003, p. 1441)

28-July 1 **Applications and Advances of Plausible and Paradoxical Reasoning for Data Fusion (DSmT)**, Stockholm, Sweden. (Feb. 2004, p. 278)

28-July 2 **16th Annual International Conference on Formal Power Series and Algebraic Combinatorics**, University of British Columbia, Vancouver, BC, Canada. (Dec. 2003, p. 63)

28-July 3 **International Association for Statistical Education (IASE) 2004 Roundtable**, Lund University, Lund, Sweden. (Sept. 2003, p. 1006)

29-July 2 **Days on Diffraction-2004**, St. Petersburg Division of Steklov's Math. Inst. and St. Petersburg Univ., St. Petersburg, Russia. (Dec. 2003, p. 1441)

30-July 5 **20th International Conference on Operator Theory**, University of the West, Timisoara, Romania. (Mar. 2004, p. 358)

30-July 7 **Fourth World Congress of Nonlinear Analysts (WCNA2004)**, Hyatt Orlando, Orlando, Florida. (Aug. 2003, p. 849)

July 2004

1-December 31 **Wall Bounded and Free-Surface Turbulence and Its Computation**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Aug. 2003, p. 849)

4-7 **ISSAC-2004: International Symposium on Symbolic and Algebraic Computation**, University of Cantabria, Santander, Spain. (Mar. 2004, p. 359)

4-8 **Joint Summer Research Conference: Algebraic Geometry: Presentations by Young Researchers**, Snowbird Resort, Snowbird, Utah. (Feb. 2004, p. 279)

4-11 **The 10th International Congress on Mathematical Education**, Copenhagen, Denmark. (Oct. 2003, p. 1129)

5-8 **International Workshop on Orthogonal Polynomials: Orthogonal Polynomials and Mathematical Physics**, Escuela Politecnica Superior of the Universidad Carlos III de Madrid, Leganes, Madrid, Spain. (Mar. 2004, p. 359)

5-9 **8th International Conference on p-Adic Functional Analysis**, University Blaise Pascal, Clermont-Ferrand, France. (Dec. 2003, p. 1441)

5-9 **Eleventh International Conference on Fibonacci Numbers and Their Applications**, Braunschweig, Germany. (Dec. 2003, p. 1441)

5-9 **Graphes et Combinatoire, un Colloque a la Memoire de Claude Berge**, Université Paris 6, Paris, France. (Mar. 2003, p. 409)

5-9 **Iwasawa 2004**, Université de Franche-Comte, Besançon, France. (May 2004, p. 574)

5-9 **19th "Summer" Conference on Topology and Its Applications**, University of Cape Town, Rondebosch, South Africa. (Sept. 2003, p. 1006)

5-10 **International Conference: 2004—Dynamical Systems and Applications**, Antalya-Pamukkale (Hierapolis), Turkey. (Mar. 2004, p. 359)

5-10 **Non-commutative Geometry and Representation Theory in Mathematical Physics**, Karlstad University, Karlstad, Sweden. (Dec. 2003, p. 1442)

5-11 **Nonstandard Mathematics**, Aveiro, Portugal.

5-14 **Workshop on the Moonshine Conjecture, Vertex Algebras, Hyperbolic Lie Algebras and Automorphic Forms**, International Centre for Mathematical Sciences, Edinburgh, United Kingdom. (Jan. 2004, p. 63)

5-15 **Moonshine—the First Quarter Century and Beyond: A Workshop on the Moonshine Conjectures and Vertex Algebras**, International Centre for Mathematical Sciences, Edinburgh, United Kingdom. (Apr. 2004, p. 458)

5-16 (REVISED) **Advanced Course on Automata Groups**, Barcelona, Spain. (Apr. 2003, p. 500)

*7-9 **DIMACS Workshop and Working Group on Usable Privacy and Security Software**, DIMACS Center, Rutgers University, Piscataway, New Jersey.

Brief Description: This workshop and working group is intended to bring together security and privacy experts with human-computer interaction experts to discuss approaches to developing more usable privacy and security software. The workshop sessions on July 7 and July 8 will include invited talks and discussion. July 9 will feature a "working group" of invited participants who will spend the day identifying important problems; discussing some of the research issues raised during the workshop in more depth; and brainstorming about approaches to future research, collaboration, and more user-centered design of security and privacy software.

Participation: Participation in the workshop is open to anyone who registers (no submission necessary). Participation in the working group on July 9 is limited because of the emphasis on achieving a high degree of interactivity and discussion. Workshop participants who are interested in participating in the working group session should send a 1-page abstract or position paper describing their work relevant to this workshop to `lorrie@acm.org`. Abstracts and position papers should be submitted in plain text, HTML, or PDF formats only. All submissions must be received by April 2, 2004, and authors will be notified by April 19, 2004, as to whether they have been accepted to participate in the working group. In addition, the authors of some submissions will be invited to present 10-minute short talks about their work.

Organizers: L. Cranor, chair, Carnegie Mellon Univ., `lorrie@acm.org`; Mark Ackerman, Univ. of Michigan, `ackerm@umich.edu`; Fabian Monrose, Johns Hopkins Univ., `fabian@cs.jhu.edu`; Andrew Patrick, NRC Canada, `Andrew.Patrick@nrc-cnrc.gc.ca`; Norman Sadeh, Carnegie Mellon Univ., `sadeh@cs.cmu.edu`.

Local Arrangements: Maria Mercado, DIMACS Center, `mercado@dimacs.rutgers.edu`, 732-445-5928.

Deadlines: Abstracts and position papers: April 2, 2004. Registration: June 30, 2004.

Information: `http://dimacs.rutgers.edu/Workshops/Tools/`; `http://dimacs.rutgers.edu/Workshops/WGTools/`.

* 7-12 **Polynomial-Based Cryptography**, Melbourne, Australia.

Speakers: Daniel Bernstein, John Cannon, Kwangjo Kim, Arjen Lenstra, Tsuyoshi Takagi, Edlyn Teske.

Organizers: Hugh Williams, Andreas Stein, Igor Shparlinski, Kathy Horadam, Lynn Batten.

Deadline: For submission of abstracts: June 4, 2004.

Information: `http://www.it.deakin.edu.au/cryptography2004`.

7-20 **MSRI-PIMS Summer Graduate Programme: Knots and 3-Manifolds**, University of British Columbia, Vancouver, BC, Canada. (Apr. 2004, p. 458)

* 8 **Internet Accessible Mathematical Computation Workshop at ISSAC 2004—First Announcement and Call for Submissions**, University of Cantabria, Santander, Spain.

Topics: Everyone with an interest in the many aspects of making mathematical computation or information accessible on the Web/Internet is welcome to attend. Topics of the workshop include, but are not limited to: Remote access to mathematical software over the Internet; Encoding of mathematical expressions (including XML, text and binary encodings) used for email, HTML embedding, digital libraries, computer algebra systems, and other scientific applications; Interoperability between software that creates/transforms/displays mathematical expressions (e.g. symbolic, numeric, graphics, text-processing packages); Web-based mathematics education; Access and interoperability to mathematical knowledge bases; Protocols, APIs, URL schemes, metadata, and other mechanisms for system interoperability, parallel/distributed computing, and standardization; Application of IAMC for practical purposes such as scientific publishing and archiving, distributed problem solving, etc.

Invited Speakers: Mike Dewar, Numerical Algorithm Group Ltd., Project Manager Mathematics on the NET, ESPRIT Project; Patrick Ion, Mathematical Reviews, American Mathematical Society, Chair, World Wide Web Consortium Math Working Group.

Information: ISSAC homepage: `http://www.risc.uni-linz.ac.at/issac2004`. IAMC homepage: `http://www.orcca.on.ca/conferences/iamc2004`.

8-10 **From Arithmetic to Cryptology: Conference on the Occasion of Gerhard Frey's 60th Birthday**, University of Duisburg-Essen, Essen Campus, Essen, Germany. (Mar. 2004, p. 359)

* 9 **DIMACS Working Group on Usable Privacy and Security Software**, DIMACS Center, Rutgers University, Piscataway, New Jersey.

Short Description: This workshop and working group is intended to bring together security and privacy experts with human-computer interaction experts to discuss approaches to developing more usable privacy and security software. The workshop sessions on July 7 and July 8 will include invited talks and discussion. July 9 will feature a "working group" of invited participants who will spend the day identifying important problems, discussing some of the research issues raised during the workshop in more depth, and brainstorming about approaches to future research, collaboration, and more user-centered design of security and privacy software.

Organizers: Lorrie Cranor, Chair, Carnegie Mellon University, `lorrie@acm.org`; Mark Ackerman, University of Michigan, `ackerm@umich.edu`; Fabian Monrose, Johns Hopkins University, `fabian@cs.jhu.edu`; Andrew Patrick, NRC Canada, `Andrew.Patrick@nrc-cnrc.gc.ca`; Norman Sadeh, Carnegie Mellon University, `sadeh@cs.cmu.edu`.

Local Arrangements: Maria Mercado, DIMACS Center, `mercado@dimacs.rutgers.edu`, 732-445-5928.

Deadline: Registration: June 30, 2004.

Information: Visit `http://dimacs.rutgers.edu/Workshops/WGTools/`.

11-14 **SIAM Conference on the Life Sciences (LS04)**, Oregon Convention Center, Portland, Oregon. (Dec. 2003, p. 1442)

11-15 **Joint Summer Research Conference: Representations of Algebraic Groups, Quantum Groups, and Lie Algebras**, Snowbird Resort, Snowbird, Utah. (Feb. 2004, p. 279)

* 11-17 **Reconnect Conference: Folding and Unfolding in Computational Geometry**, St. Mary's College, Moraga, California.

Principal Speaker: J. O'Rourke, Smith College, email: `orourke@cs.smith.edu`.

Organizers: R. Leibowitz, Wheaton College (`rochelle_leibowitz@wheatonma.edu`); F. S. Roberts, Rutgers University (`froberts@dimacs.rutgers.edu`).

Information: `http://dimacs.rutgers.edu/reconnect/`. Contact: email: `reconnect@dimacs.rutgers.edu`, tel: 732-445-5928.

11-17 **XI Meeting on Real Analysis and Measure Theory (CARTEMI)**, Hotel Continental Terme, Ischia, Naples, Italy. (Apr. 2004, p. 458)

12-13 **Workshop on Logical Foundations of an Adaptive Security Infrastructure (WOLFASI)**, Turku, Finland. (May 2004, p. 574)

* 12-15 **Canada-France Meeting of Mathematics**, Centre de Congrés Pierre Baudis, Toulouse, France.

Plenary Speakers: G. Allaire, École Polytech., Palaiseau; M. Artigue, Univ. Paris VI, Jussieu; M. Bergounioux, Univ. d'Orléans; J. Borwein, Dalhousie Univ.; D. Brillinger, Univ. of California, Berkeley; A. Connes, IHÉS et Collège de France; W. Craig, McMaster Univ.; H. Darmon, McGill Univ.; E. Giroux, CNRS et ENS Lyon; L. Lafforgue, IHÉS; G. Lugosi, Pompeu Fabra Univ., Barcelona; M. Lyubich, Univ. of Toronto; C. Reutenauer, Univ. du Québec à Montréal; A.-S. Sznitman, ETH, Zurich; M. S. Taqqu, Boston Univ.; H. Wolkowicz, Univ. of Waterloo.

Chair of Scientific Committee: F. H. Clarke, Univ. Claude Bernard-Lyon I.

Special Sessions: Operator algebras, Symplectic topology and geometry, Number theory, The Langlands program, Spectral and geometric analysis, Partial differential equations, Dynamical systems, Differential equations and control, Variational analysis and optimization, Stochastic analysis, Multifractals and long memory processes, The probability/statistics interface, Statistical analysis of functional data, Numerical analysis, Low dimensional topology and geometric group theory, Mathematical biology, Complex dynamical systems, Poster session.

Information: `http://cms.math.ca/Events/Toulouse2004/`; `http://smc.math.ca/Reunions/Toulouse2004/`; email: `marie-line.chemin@math.ups-tlse.fr`.

12-15 **8th WSEAS CSCC**, Vouliagmeni, Athens, Greece. (Feb. 2004, p. 279)

12-15 **First Joint Canada-France Meeting of the Mathematical Sciences**, Centre de Congrès Pierre Baudis, Toulouse, France. (May 2004, p. 575)

12-16 **School on Atmospheric Sciences and Climate Dynamics**, IST, Lisbon, Portugal. (Apr. 2004, p. 458)

*14-17 **Nineteenth Annual IEEE Symposium on Logic in Computer Science (LICS 2004)**, Turku, Finland.

Description: The LICS Symposium is an annual international forum on theoretical and practical topics in computer science that relate to logic in a broad sense. LICS 2004 will be held in conjunction with the thirty-first International Colloquium on Automata, Languages, and Programming (ICALP 2004).

Program Chair: H. Ganzinger (`hg@mpi-sb.mpg.de`).

Information: `http://www.lfcs.informatics.ed.ac.uk/lics`; `http://www.math.utu.fi/ICALP04/WScall.html`.

16-19 **XIIIth Oporto Meeting on Geometry, Topology and Physics**, Faculty of Sciences, University of Oporto, Oporto, Portugal. (May 2004, p. 575)

16-20 **Algebraic Topology in Computer Science Workshop**, University of Western Ontario, London, Ontario, Canada. (Apr. 2004, p. 458)

18-23 **International Conference on Differential Equations and Applications in Mathematical Biology**, Malaspina University College, Nanaimo, British Columbia, Canada. (Apr. 2004, p. 458)

18-23 **Joint Summer Research Conference: Gaussian Measure and Geometric Convexity**, Snowbird Resort, Snowbird, Utah. (Feb. 2004, p. 279)

18-24 **Workshop on Mathematical Ideas in Nonlinear Optics: Guided Waves in Inhomogenous Media**, International Centre for Mathematical Sciences, Edinburgh, United Kingdom. (Jan. 2004, p. 63)

19 or 20 **The Second International Workshop on Declarative Agent Languages and Technologies (DALT-2004)**, The Third International Joint Conference on Autonomous Agents & Multi-Agent Systems (AAMAS 2004), New York, New York. (Apr. 2004, p. 458)

19-22 **11th Conference of the International Linear Algebra Society**, University of Coimbra, Coimbra, Portugal. (Apr. 2004, p. 459)

*19-22 **Eleventh Workshop on Logic, Language, Information and Computation (WoLLIC'2004)**, Fontainebleau, Paris, France.

Description: This is the eleventh in a series of workshops intended to foster interdisciplinary research in pure and applied logic.

Speakers (tentative): T. Ehrhard, K. Meer, D. Niwinski, L. Ong, G. Paun, A. Rabinovich, and S. Shieber.

Support: Graduate students and recent Ph.D.'s in logic may apply for modest grants to attend the workshop; the deadline for applications is March 1, 2004.

Information: `http://www.cin.ufpe.br/~wollic/wollic2004/`.

*19-23 **Com2MaC 2004 Conference on Association Schemes, Codes, and Designs**, POSTECH, Pohang, South Korea.

Topics: Association schemes, combinatorial designs, error-correcting codes, finite geometry, distance-regular graphs, orthogonal polynomials and special functions.

Plenary Speakers: E. Bannai (Japan), A. Brouwer (The Netherlands), C. Godsil (Canada), A. A. Ivanov (UK), T. Ito (Japan), J. H. Koolen (Korea), A. Munemasa (Japan), V. Pless (USA), P. Terwilliger (USA), J. A. Thas (Belgium), H. Van Maldeghem (Belgium).

Conference Advisory Board: C. Colbourn (USA), S. G. Hwang (Korea), J. H. Kwak (Korea), M. Ozeki (Japan), C. E. Praeger (Australia), D. K. Ray-Chaudhuri (USA), J. Stufken (USA), V. Tonchev (USA), J. van Lint (The Netherlands), W. Wallis (USA), Z.-X. Wan (China).

Program Committee: S. Bang, H. Blau, J. Caughman, J. R. Cho, B. Curtin, W. Haemers, M. Hirasaka, T. Huang, D. S. Kim, H. K. Kim, M. Klin, J. Koolen (co-chair), M. Lang, W. Martin, A. Munemasa, M. Muzychuk, J. Balmaceda, H. Shen, S. Y. Song (co-chair), P.-H. Zieschang.

Important Dates: May 1, 2004: Submission deadline for abstracts to be invited. May 15, 2004: Notification of invitation. May 31, 2004: Registration deadline. July 15, 2004: Submission deadline for full manuscript of the talks. July 19-23, 2004: Conference.

Registration Fee: US\$200 (before May 31, 2004), US\$250 (after May 31, 2004); students/unemployed persons: US\$100 (before May 31, 2004), US\$125 (after May 31, 2004). The Com^{2}MaC will cover local expenses for invited speakers and student participants upon request.

Information: Conference Director: Dr. Hyun Kwang Kim; email: `hkkim@postech.ac.kr`; `http://com2mac.postech.ac.kr/conference/conf2004`; or write to `conf2004@com2mac.postech.ac.kr` or email: `sysong@iastate.edu`.

19-23 **Knots in Vancouver: Workshop in Knot Theory and 3-Manifolds**, PIMS, University of British Columbia, Vancouver, BC, Canada. (Apr. 2004, p. 459)

19-23 **Quantum Information and Quantum Control Conference**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 459)

19-23 **Tensor Decompositions**, AIM Research Conference Center, Palo Alto, California. (May 2004, p. 575)

19-23 **XVIII Escola de Algebra (Eighteenth Algebra School)**, State University of Campinas (UNICAMP), Campinas, SP/Brazil. (Oct. 2003, p. 1129)

19-24 **School and Workshop on Oceanography, Lakes and Rivers**, IST, Lisbon, Portugal. (Apr. 2004, p. 459)

19-31 **The 7th International Diffiety School**, Santo Stefano del Sole, Italy. (May 2004, p. 575)

19-August 6 **Summer School and Conference on Dynamical Systems**, ICTP, Trieste, Italy. (Feb. 2004, p. 279)

*21-23 **Special Session: Computer Algebra and Coding Theory at the 10th IMACS International Conference on Applications of Computer Algebra**, Lamar University, Beaumont, Texas.

Information: Edgar Martínez-Moro; email: `edgar.martinez@ieee.org`.

24-28 **European Congress on Computational Methods in Applied Sciences and Engineering**, Jyväskylä, Finland. (Feb. 2003, p. 295)

25-31 **2004 ASL European Summer Meeting (Logic Colloquium '04)**, Torino, Italy. (June/July 2003, p. 725)

26-30 **Algebraic Groups, Arithmetic Groups, Automorphic Forms and Representation Theory: An International Conference in Memory of Armand Borel**, Center of Mathematical Sciences, Zhejiang University, Hangzhou, China. (Mar. 2004, p. 360)

26-30 **IMS Annual Meeting/6th Bernoulli World Congress**, Barcelona, Spain. (Aug. 2003, p. 849)

26–30 **Workshop on Spectral Theory of Schrödinger Operators**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 849)

* 26–30 **XIII School of Differential Geometry, Dedicated to the memory of José Fernando Escobar**, Institute of Mathematics and Statistics, University of São Paulo, Brazil.

Description: The following activities are planned for the event: five short courses in topics at intermediate/advanced doctoral level, plenary lectures given by the invited speakers, communications, short communications, and posters. In order to encourage the participation of students, we also plan to have eight poster sections. Proposals for communications will be accepted until May 30, 2004.

Information: email: `xiiiescolagd@ime.usp.br` or `http://www.thiagorodrigo.com.br/escolagd/escolagd.php?idioma=en.http://www.ime.usp.br/~egd`.

26–30 **XIV Brazilian Topology Meeting**, Campinas, São Paulo, Brazil. (Sept. 2003, p. 1007)

30–August 1 **The Seventh Annual International Conference of Bridges: Mathematical Connections in Art, Music, and Science**, Southwestern College, Winfield, Kansas. (Jan. 2004, p. 63)

* 31–August 4 **International Conference on Representation Theory, III**, Sichuan University, Chengdu, People's Republic of China.

Description: This is the third conference in the series including the Shanghai conference (the International Conference on Representation Theory, held at East China Normal University, June 29–July 3, 1998) and the Kunming conference (the International Conference on Representations of Algebraic Groups and Quantum Groups, July 22–28, 2001).

Main Speakers: Dan Barbasch (Cornell Univ., USA), Stephen Berman (Univ. of Saskatchewan, Canada), Jon F. Carlson (Univ. of Georgia, USA), Shun-Jen Cheng (National Taiwan Univ., Taiwan), Bangming Deng (Beijing Normal Univ., China), Congying Dong (Univ. of California at Santa Cruz, USA), Yun Gao (York Univ., Canada), Robert L. Griess, Jr. (Univ. of Michigan, USA), Roger Howe (Yale Univ., USA), Jun Hu (Beijing Inst. of Tech., China), Seok-Jin Kang (Korea Inst. for Adv. Study, Korea), Alexander Kleshchev (Univ. of Oregon, USA), Shrawan Kumar (Univ. of North Carolina, USA), Gus I. Lehrer (Univ. of Sydney, Australia), Haisheng Li (Rutgers Univ., USA), Jianshu Li (The Hong Kong Univ. of Sci. and Tech., Hong Kong), Yanan Lin (Xiamen Univ., China), Zongzhu Lin (Kansas State Univ., USA), Kefeng Liu (Univ. of California at Los Angeles, USA), George Lusztig (MIT, USA), Olivier Mathieu (Univ. Claude-Bernard (Lyon 1), France), Hiraku Nakajima (Kyoto Univ., Japan), Daniel K. Nakano (Univ. of Georgia, USA), Brian J. Parshall (Univ. of Virginia, USA), Hebing Rui (East China Normal Univ., China), Idun Reiten (Norwegian Univ. of Sci. and Tech., Norway), Leonard Scott (Univ. of Virginia, USA), Shaobin Tan (Xiamen Univ., China), Weiqiang Wang (Univ. of Virginia, USA), Nanhua Xi (Chinese Acad. of Sci., China), J. Zhang (Univ. of Washington, USA), Jiping Zhang (Peking Univ., China), Ruibin Zhang (Univ. of Sydney, Australia), Yongchang Zhu (The Hong Kong Univ. of Sci. and Tech., Hong Kong).

Deadline: The deadline is June 30, 2004. Some additional lectures can be arranged on basis of abstracts provided by participants.

Information: Please send your abstract (a LaTex file) to Liangang Peng, `penglg@mail.sc.cninfo.net`, or Jie Xiao, `jxiao@math.tsinghua.edu.cn`. For further information, you can contact: Liangang Peng, `penglg@mail.sc.cninfo.net`; `http://www.scu.edu.cn/home/math`.

August 2004

* 1–5 **11th International Conference on Geometry and Graphics (ICGG 2004)**, Quangzhou, China.

Organizer: Zongyi Zuo, email: `zuo@gdut.edu.cn`,

Information: Contact local organizer; or Gunter Weiss, email: `weiss@math.tu-dresden`; visit `http://www.isgg.tu-dresden.de`.

* 1–7 **8th Brazilian School of Probability**, Ubatuba, Sao Paulo, Brazil.

Description: The school is intended as a forum to discuss new developments in probability and related areas, an occasion to detect new directions of research and to establish new collaborations. Activities will include minicourses, plenary talks by invited speakers, short communications, and problem sessions.

The school is concentrated in probability and stochastic processes. This year the topics are: fragmentation, random surfaces, hydrodynamics, random motion in random environments, traffic models, cellular automata.

Courses: Jean Bertoin, Olle Haggstrom.

Talks: Lorenzo Bertini, Luc Devroye, Jim Fill, David Griffeath, Richard Kenyon, Alejandro Maass, Vladas Sidoravicius, Bálint Tóth.

Information: `http://www.ime.usp.br/ebp8/`.

2–5 **CSIR-Sponsored Seminar: Recent Advances in Combinatorics, Graphs and Codes and Their Applications**, Eluru, India. (Apr. 2004, p. 459)

2–6 **First Announcement: The 9th International Conference on Difference Equations and Applications ICDEA-9**, University of Southern California, Los Angeles, California. (Dec. 2003, p. 1442)

2–6 **Workshop on Dynamics in Statistical Mechanics**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 850)

2–6 **Workshop on Derived Categories, Quivers and Strings**, International Centre for Mathematical Sciences, Edinburgh, United Kingdom. (Jan. 2004, p. 63)

2–27 **Magnetic Reconnection Theory**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Apr. 2003, p. 500)

4–6 **2004 IMCC (International Math Conference at Chonbuk National University)**, Chonbuk National University, Chonju, Chonbuk, Korea. (Jan. 2004, p. 63)

* 4–6 **Recent Advances in Operator-Related Function Theory**, Trinity College, Dublin, Ireland.

Topics: The main topic of this conference is spectral measures. Other topics include composition operators on spaces of analytic functions, Cauchy transforms, and function algebras.

Lecturers: The principal lectures will be given by A. B. Aleksandrov, K. M. Dyakonov, J. E. McCarthy, and D. Sarason.

Speakers: Confirmed speakers are J. J. Donaire, D. Girela, S. Garcia, R. Mortini, A. Nicolau, P. Nieminen, A. Poltoratski, W. Ross, E. Saksman, J. Shapiro, W. Smith.

Organizers: email: `amatheson@albany.edu`; email: `richardt@maths.tcd.ie`; email: `stessin@math.albany.edu`.

Information: `http://littlewood.math.albany.edu`.

4–6 **The Seventh North American New Researchers Conference**, York University, Toronto, Ontario, Canada. (Jan. 2004, p. 64)

5–6 **Beyond the Formula VIII: A Conference on Teaching Introductory Statistics**, Monroe Community College, Rochester, New York. (May 2004, p. 575)

5–6 **Workshop on Missing Data Problems**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 459)

6–7 **New Directions in Probability Theory**, The Fields Institute, Toronto, Ontario, Canada. (Aug. 2003, p. 850)

6–11 **17th International Conference on Multiple Criteria Decision Analysis**, Whistler, British Columbia, Canada. (Apr. 2004, p. 459)

8–11 **Euler 2004—Third Annual Meeting of the Euler Society**, Roger Williams University Conference Center, Portsmouth, Rhode Island. (Apr. 2004, p. 459)

* 8–14 **Reconnect Conference: Integrating Information from Sequence and Evolution: An Introduction to Computational Biology**, DIMACS, Rutgers University, Piscataway, New Jersey.

Principal Speaker: R. Ravi, Carnegie Mellon Univ., email: ravi@andrew.cmu.edu.

Organizers: R. Leibowitz, Wheaton College (rochelle_leibowitz@wheatonma.edu); F. S. Roberts, Rutgers University (froberts@dimacs.rutgers.edu).

Information: http://dimacs.rutgers.edu/reconnect/. Contact: email: reconnect@dimacs.rutgers.edu, tel: 732-445-5928.

9–13 **13th USENIX Security Symposium**, San Diego, California. (Dec. 2003, p. 1442)

9–13 **Moment Maps and Surjectivity in Various Geometries**, AIM Research Conference Center, Palo Alto, California. (May 2004, p. 575)

9–27 **Advanced School & Conference on Non-commutative Geometry**, ICTP, Trieste, Italy. (Feb. 2004, p. 279)

* 16–20 **Sphere Packings, Lattices, and Infinite Dimensional Algebra**, AIM Research Conference Center, Palo Alto, California.

Organizers: L. Carbone, N. Elkies, and J. Lepowsky.

Topics: This workshop, sponsored by AIM and the NSF, will focus on sphere packings and lattice packings, with particular attention to dimensions 8 and 24 and the connection with automorphic forms and Moonshine. Primarily, the workshop will consist of: (1) An investigation of the techniques of Cohn and Elkies, and of Cohn and Kumar, which are conjectured to give rise to a proof that the E_8 root lattice and the Leech lattice give the densest sphere packings in $\mathbb{R}^8$ and $\mathbb{R}^{24}$, respectively. (2) An introduction to the recent work of Frenkel, Lepowsky, and Meurman, and of Huang, which indicates deep connections between lattices, codes, and conformal field theory.

Deadline: May 16, 2004.

Information: Visit http://aimath.org/ARCC/workshops/spherepacking.html.

* 16–20 **Automorphisms of Curves**, Lorentz Center, Leiden, The Netherlands.

Aim: We will discuss the latest developments in the theory of group actions on algebraic curves, a field that has been lifted to a new level of sophistication in recent years.

Topics: Deformation theory, lifting to characteristic zero, relation to moduli of curves, patching method, techniques from fundamental groups, equivariant families, non-archimedean uniformization, and group theoretic aspects.

Organizers: Gunther Cornelissen and Frans Oort (Univ. Utrecht).

Keynote Participants: A. Abbes, P. Bradley, T. Chinburg, R. Guralnick, D. Harbater, F. Kato, S. Maugeais, R. Pries, M. Raynaud, N. Stalder, S. Wewers, M. Zieve.

Information: See http://pascal.lc.leidenuniv.nl/ under "Program Workshops, year 2004". For scientific information about this workshop, please contact the organizers directly at email: cornelis@math.uu.nl or oort@math.uu.nl.

16–December 17 **Quantum Information Science**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Apr. 2003, p. 500)

* 17–19 **6th WSEAS International Conference on Applied Mathematics**, Corfu Island, Greece.

Symposia: Linear Algebra and Applications; Numerical Analysis and Applications; Differential Equations and Applications; Probabilities; Statistics; Operational Research; Optimization; Algorithms; Discrete Mathematics; Systems; Communications; Control, Computers, Education.

Other Conferences: Mathematical Biology and Ecology, Fluid Mechanics, Heat and Mass Transfer.

Information: http://www.wseas.org.

17–20 **Degenerate PDEs and Singular Geometries**, University of Potsdam, Potsdam, Germany. (Apr. 2004, p. 460)

* 19–20 **DIMACS Working Group on the Burrows–Wheeler Transform: Ten Years Later**, DIMACS Center, Rutgers University, Piscataway, New Jersey.

Short Description: On May 10, 1994, Michael Burrows and David Wheeler published the Technical eport *A block sorting lossless data compression algorithm* describing a new data compression algorithm based on a reversible transformation of the input. This transformation had a profound impact in several algorithmic fields and is today universally known as the BWT: the Burrows-Wheeler Transform.

The BWT changed the approach to data compression in a twofold way: it highlighted the role of input transformations to prepare data for achieving better compression and showed that a pipeline of simple encoders may be more effective than a one-shot compression pass. The BWT has also revolutionized the field of indexing data structures: using the BWT it is possible to build the so-called "compressed indexes", a new family of data structures that support powerful substring searches and occupy roughly the same space required by the best compressors.

Sponsor: DIMACS.

Organizers: Paolo Ferragina, University of Pisa; Giovanni Manzini, University of Piemonte Orientale; S. Muthukrishnan, Rutgers University, email: muthu@cs.rutgers.edu.

Information: http://dimacs.rutgers.edu/Workshops/BWT/.

* 23–26 **Workshop on Harmonic Analysis and Homogenoeus Spaces**, Leiden University, Leiden, The Netherlands.

Information and Registration: http://www.lc.leidenuniv.nl/lc/web/2004/20040823/info.php3?wsid=122.

23–September 2 **International Conference-School on Geometry and Analysis Dedicated to the 75th Anniversary of Academician Yu. G. Reshetnyak**, Sobolev Institute of Mathematics, Novosibirsk, Russia. (Apr. 2004, p. 460)

24–27 **International Conference on Nonlinear Operators, Differential Equations and Applications (ICNODEA-2004)**, Babes-Bolyai University, Cluj-Napoca, Romania. (Sept. 2003, p. 1008)

* 24–28 **Geometric Topology, Discrete Geometry and Set Theory (in Celebration of the Centennial of L. V. Keldysh)**, Steklov Institute and Moscow State University, Moscow, Russia.

Chairman: Sergey Novikov (RAS).

Sections: Geometric Topology (A. V. Chernavsky , E. V. Shchepin); Set Theory (V. V. Fedorchouk, V. G. Kanovei, V. A. Lyubetsky); Topology of Low Dimensions (S. V. Matveev, I. A. Dynnikov); Combinatorial Geometry and Algebraic Topology (V. M. Buchstaber).

Topics: Geometric topology of continua and manifolds, homeomorphisms and embeddings, topology of dimensions 2–4, knots, algorithmic questions, discrete geometry, algebraic topology, general topology, descriptive set theory, foundations of mathematics.

Information: http://keldysh-100.mi.ras.ru/.

29–September 4 **Seventh International Workshop on Complex Structures and Vector Fields**, Plovdiv, Bulgaria. (Mar. 2004, p. 360)

* 30–September 3 **Algebraic Cycles and Motives**, Lorentz Center, Leiden, The Netherlands.

Organizers: B. Edixhoven, J. Nagel.

Scientific Coordinator: C. Peters.

Tentative List of Speakers: L. Barbieri Viale, A. Beauville. S. Bloch, J.-L. Colliot-Thélène (*), A. Conte, F. Deglise (*), C. Deninger, H. Esnault, P. Griffiths (*), M. Hanamura, U. Jannsen, K. Kuenemann (*), S. Mueller-Stach, A. Otwinowska (*), D. Ramakrishnan, S. Saito, C. Schoen (*), T. Scholl, T. Shioda, C. Soulé (*), T. Springer, V. Srinivas, B. van Geemen (*), A. Verra, C. Voisin (*). (*) to be confirmed.

Information: http://www.lc.leidenuniv.nl/lc/web/program.php3?jaar=2004.

* 30–September 3 **7th French-Romanian Colloquium in Applied Mathematics**, Craiova, Romania.

Invited Speakers: Vlad Bally (Paris), Catherine Bandle (Basel), Jean-Yves Chemin (Paris), Philippe G. Ciarlet (Paris and Hong Kong), Alain Damlamian (Paris), George Dinca (Bucharest), Cristian Faciu (Bucharest), Olivier Goubet (Amiens), George Haiman (Lille), Dragos Iftimie (Lyon), Petru Jebelean (Timisoara), Claude Le Bris (Paris), Bernadette Miara (Noisy-le-Grand), Sorin Micu (Craiova), Gheorghe Nenciu (Bucharest), Dan Polisevschi (Bucharest), Radu Precup (Cluj), Tudor Ratiu (Lausanne), Mircea Sofonea (Perpignan), Michel Théra (Limoges).

Invited Sessions: Contrôle des systèmes gouvernés par des équations aux dérivées partielles, organized by Marius Tucsnak (Nancy I); Homogénéisation et applications aux sciences des matériaux, organized by Horia Ene (Bucharest); Mathématiques financières, organized by Radu Tunaru (London); Biomécanique, organized by Marc Thiriet (Paris); Inégalités et applications, organized by Constantin Niculescu (Craiova).

Contacts: Matei Basarab, Laboratoire Jacques-Louis Lions, Université Paris 6, 175 rue du Chevaleret, 75013 Paris, France; email: `matei@ann.jussieu.fr`. Vicentiu Radulescu, Department of Mathematics, University of Craiova, 200 585 Craiova, Romania; email: `colloque@inf.ucv.ro`.

Information: Additional information about the colloquium may be obtained at: `http://www.inf.ucv.ro/colloque2004`.

30–September 3 **9th Conference on Differential Geometry and Its Applications**, Prague, Czech Republic. (Apr. 2003, p. 500)

30–September 3 **Geometric and Ergodic Theory of Dynamical Systems—a Workshop in Honor of the 60th Birthday of C. Gutierrez and M. A. Teixeira**, ICMC-USP, Sao Carlos-SP, Brazil. (May 2004, p. 575)

September 2004

1–6 (REVISED) **Sixth Pan-African Congress of Mathematicians**, Institute National des Sciences Appliquees et del la Technologie (INSAT), Université 7 Novembre à Carthage, Tunis, Tunisia. (May 2003, p. 604)

2–4 **2nd International Conference on Soft Methods in Probability and Statistics**, Edificio Historico de la Universidad, Oviedo, Spain. (Jan. 2004, p. 64)

*7 **The DIMACS Symposium on Phylogenetics and Rapidly Evolving Pathogens**, Aotea Centre, Auckland, New Zealand.

Description: This working group will build on phylogenetic methods developed by computational biologists to explore ways in which such methods can be applied and developed to shed new light on the origin, evolution, and likely future development of viruses and other pathogens. Phylogeny is now a central tool for studies into the origin and diversity of viruses such as HIV and dengue fever virus. These and other investigations have provided new insights, such as identifying the possible pattern of transfer of HIV-type viruses between primate species. Phylogenetic techniques have also proved useful in mapping the evolution of different strains of the human influenza A virus, with the goal of predicting which strain is most likely to cause future epidemics, with applications to vaccine development.

Sponsor: DIMACS.

Organizers: Allen Rodrigo, Univ. of Auckland, email: `a.rodrigo@auckland.ac.nz`; Mike Steel, Univ. of Canterbury, email: `M.Steel@math.canterbury.ac.nz`.

Deadlines: This meeting is by invitation only. Student posters are welcome. If you are interested in participating, please contact the organizers.

Information: `http://dimacs.rutgers.edu/Workshops/WGPhylogeneticTrees/`.

7–11 **2004 Workshop on Algebraic Geometry and Physics**, Instituto Superior Tecnico (IST), Lisbon, Portugal. (Apr. 2004, p. 460)

*9–12 **Recent Trends in Additive Combinatorics**, AIM Research Conference Center, Palo Alto, California.

Topics: This workshop, sponsored by AIM and the NSF, will focus on four interrelated themes: (1) Long arithmetic progressions and the Szemeredi regularity lemma; (2) the Erdös-Szemeredi sum-product conjecture, the Erdös distance set problem, and Szemeredi-Trotter type problems in various dimensions and fields; (3) Freiman's inverse theorem and sum-sets; (4) the Kakeya conjecture in finite fields, and related problems from harmonic analysis. There have been a number of recent breakthroughs in each of these fields involving new techniques, and the goal of the workshop is to popularize these new techniques with people working in neighboring fields.

Organizers: T. Tao and V. Vu.

Deadline: June 9, 2004.

Information: `http://aimath.org/ARCC/workshops/additivecomb.html`.

10–14 **International Conference of Numerical Analysis and Applied Mathematics 2004 (ICNAAM 2004)**, Chalkis, Greece. (Mar. 2004, p. 360)

13–17 **Homogenization and Shape Optimization—Summer School 2004**, University of Lisbon, Lisbon, Portugal. (May 2004, p. 575)

*14–16 **4th WSEAS International Conference on Simulation, Modeling and Optimization (ICOSMO 2004)**, Izmir, Turkey.

Information: `http://www.wseas.org`.

14–18 (REVISED) **Third International Conference on Boundary Integral Methods: Theory and Applications**, University of Reading, United Kingdom. (Nov. 2002, p. 1287)

*16–19 **Algebraic Cycles, K-Theory, and Modular Representation Theory (in Honor of the 60th Birthday of Eric Friedlander)**, Northwestern University, Evanston, Illinois.

Sponsors: The Clay Mathematics Institute, the National Security Agency, the National Science Foundation, and Northwestern University.

Description: The theme of the conference will be a survey of the state of the art in algebraic cycles, K-theory, and modular representation theory, in particular as influenced by the work of Eric Friedlander. The conference will feature several keynote talks that will survey the historical background, current state of development, and prospects for future progress in all of the focused areas. These talks will be particularly valuable for young researchers. Other talks will present recent developments in the focused areas.

Speakers Include: D. Benson (Georgia), S. Bloch (Chicago), D. Cox (Amherst), W. Dwyer (Notre Dame), B. Lawson (Stony Brook), S. Lichtenbaum (Brown), B. Mazur (Harvard), D. Nakano (Georgia), B. Parshall (Virginia), A. Suslin (Northwestern), V. Voevodsky (IAS), M. Walker (Nebraska), C. Weibel (Rutgers).

Organizers: C. Bendel (Wisconsin-Stout), D. Cox (Amherst), C. Haesemeyer (Illinois), R. Joshua (Ohio State), J. Pevtsova (Oregon).

Funding: Funding is available to support the expenses of graduate students and recent graduates. Requests for support must be received by July 31, 2004.

Information: `http://www.math.northwestern.edu/conferences/friedlander/`.

*17–18 **Zirkumferenz 2004**, Aula der Mädchenrealschule des Zisterzienserinnenklosters in Waldsassen, Bavaria, Germany.

Description: An interdisciplinary dialogue on science, mathematics, philosophy, and art involving the number π.

Organizers: Hael Yxxs and J. V. Schmidt.

Information: `http://www.zirkumferenz.de`.

*18–20 **Workshop on Harmonic Analysis and Number Theory**, University of Exeter, Exeter, United Kingdom.

Organizers: Nigel Byott and Anton Deitmar.

Speakers: D. Bump, K. Buzzard, S. deBacker, M. Harris, G. Henniart, W. Hoffmann, R. Langlands, C. Moeglin, W. Mueller, F. Murnaghan.
Information: email: `a.h.j.deitmar@ex.ac.uk`.

19-22 **The First International Conference on Complex Systems CSIMTA 2004 (Complex Systems Intelligence and Modern Technology Applications)**, Cherbourg, France. (Oct. 2003, p. 1129)

20-22 **Workshop on Elliptic Curve Cryptograpy**, Ruhr University, Bochum, Germany. (Mar. 2004, p. 360)

*20-21 **DIMACS Workshop on Reticulated Evolution**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Sponsor: DIMACS.
Organizers: Mel Janowitz, DIMACS, email: `melj@dimacs.rutgers.edu`; Randy Linder, University of Texas, email: `rlinder@mail.utexas.edu`; Bernard Moret, University of New Mexico, email: `moret@cs.unm.edu`.
Short Description: Species evolution has long been modeled as a branching process that can uniquely be represented by a tree topology. In such a topology, each species can only be linked to its closest ancestor, while interspecies relationships such as species hybridization or lateral gene transfer in bacteria are not allowed. With the advent of phylogenetic analysis at the molecular level, there is increasing evidence that such a model is inadequate. This workshop will explore the history and latest status of these new models of "reticulate evolution" and will be coupled with a smaller working group meeting designed to explore promising avenues for future research.
Deadlines: Main speakers are by invitation only. Workshop participants may submit papers by contacting one of the organizers no later than August 1, 2004.
Information: `http://dimacs.rutgers.edu/Workshops/Reticulated/`.

20-24 **2004 IEEE/WIC/ACM International Conference on Web Intelligence (WI'04)**, King Wing Hot Spring Hotel, Beijing, China. (Mar. 2004, p. 361)

20-24 **12th French-German-Spanish Conference on Optimization**, University of Avignon, Avignon, France. (Jan. 2004, p. 64)

*20-24 **Analysis and Applied Mathematics Summer School**, Univ. Roma "La Sapienza", Roma, Italy.
Organizers: V. Chiado' Piat (Politecnico di Torino), A. Garroni (Univ. di Roma "La Sapienza",) C. Mantegazza (Scuola Normale Superiore di Pisa).
Speakers: Xavier Cabré (ICREA-Univ. Politecnica de Catalunya), Phase Transition Layers, Minimal Surfaces and Ground States; Giovanna Citti (Univ. di Bologna), Real Analysis in Lie Groups and Perceptual Completions; Gianni Dal Maso (SISSA, Trieste), Variational Models in Fracture Mechanics; Barbara Niethammer (Humboldt Univ., Berlin), Averaging Techniques for Models of Phase Transitions.
Registration: There is no registration fee, but interested people are requested to register by sending an email to Valeria Chiado' Piat at `valeria.chiadopiat@polito.it`.
Funds: Limited funds are available for young researchers to cover accommodations in double rooms. For information, please contact Valeria Chiado' Piat at the address above.
Information: Please see `http://cvgmt.sns.it/roma2004`.

*20-24 **IMA Tutorial: Mathematics of Materials**, University of Minnesota, Minneapolis, Minnesota.
Organizers: M.-C. Calderer (UMN), P. J. Sternberg (Indiana).
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/`.

*20-24 **The Second International Course of Mathematical Analysis in Andalucia**, Facultad de Ciencias, University of Granada, Granada, Spain.
Description: Our aim is to give an extensive overview of new directions and advances in mathematical analysis. Therefore the researcher is invited to get into topics that seem promising as guidelines for current and future research in this interesting area of mathematics. Leading researchers in the field will provide us with a nice variety of topics and open problems, showing also some tools and techniques that have been helpful in similar situations. To this goal, we offer both seminars and one-hour talks. While the one-hour talks are intended to provide an overview on a variety of current topics, the seminars will extend over several days and will therefore allow an in-depth discussion of certain specific subjects.
Invited Speakers: Richard M. Aron (Kent State Univ., USA), Fernando Bombal (Univ. Complutense de Madrid, Spain), José Bonet (Univ. Politécnica de Valencia, Spain), Javier Duoandikoetxea (Univ. del País Vasco, Spai), Miguel de Guzmán (Univ. Complutense de Madrid, Spain), Gilles Godefroy (Univ. Paris VI , France), William B. Johnson (Texas A&M Univ., USA), Nigel J. Kalton (Univ. of Missouri, USA), Michael Neumann (Mississippi State Univ., USA), Lawrence Narici (St. John's Univ., New York, USA), Kristian Seip (Norwegian Univ. of Sciences and Technology, Norway), Manuel Valdivia (Univ. de Valencia, Spain), Joan Verdera (Univ. Autónoma de Barcelona, Spain), Felipe Zó (Univ. Nacional de San Luis, Argentina).
Organizing/Local Committee: M. Dolores Acosta, Julio Becerra, Antonio Moreno, Antonio Peralta.
Information: `http://www.ugr.es/local/amandal`, where one can register on-line, or email: `amandal@ugr.es`.

20-30 **Stochastic Finance 2004 (StochFin2004)**, Coimbra and Lisbon, Portugal. (Mar. 2004, p. 361)

*22 **DIMACS Working Group on Reticulated Evolution**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Short Description: Species evolution has long been modelled as a branching process that can uniquely be represented by a tree topology. In such a topology, each species can only be linked to its closest ancestor, while interspecies relationships such as species hybridization or lateral gene transfer in bacteria are not allowed. With the advent of phylogenetic analysis at the molecular level, there is increasing evidence that such a model is inadequate. This working group meeting is coupled with a workshop on the same subject. Its goal will be to initiate promising avenues of research designed to explore new models of "reticulate evolution" that are biologically meaningful and computationally feasible. Attendance will be by invitation only.
Sponsor: DIMACS.
Organizers: Mel Janowitz, DIMACS, email: `melj@dimacs.rutgers.edu`; Randy Linder, University of Texas, email: `rlinder@mail.utexas.edu`; Bernard Moret, University of New Mexico, email: `moret@cs.unm.edu`.
Deadlines: Participation is by invitation only. If you wish an invitation, please contact one of the organizers.
Information: `http://dimacs.rutgers.edu/Workshops/Reticulated\_WG/`.

*23-25 **Austrian Workshop on Asset Liability Management in Insurance**, Vienna University of Technology, Vienna, Austria.
Program: Professors from universities in Vienna and experts from the industry will give an introductory crash course for those who are not yet experts in the field of asset-liability management for insurance companies, especially with respect to mathematical concepts and methods. This half-day series of lectures is held in German. The second day will feature a range of sessions with experts from the industry in Austria, Germany, and Switzerland. The sessions will be held in English in order to enable non-German speakers to take part in the discussions. The third day will feature sessions with internationally renowned academic researchers in the field of mathematical methods in insurance.
Organizers: M. Fulmek (Vienna University/INFORM); T. Hudetz (Financial Market Authority/INFORM); M. Jeckle (Univ. of Applied

Sciences BFI Vienna); C. Krischanitz (AVOe, arithmetica); S. Pichler (WU Wien); M. Predota (Austrian Financial Market Authority); W. Schachermayer (FAM@TUWien/INFORM); H. Schicketanz (FJH); U. Schmock (FAM@TU Wien).
Information: `http://alm.fam.tuwien.ac.at`.

*27–30 **9th European Conference on Logics in Artificial Intelligence**, Lisbon, Portugal.
Aim and Scope: The aim of the 9th European Conference on Logics in Artificial Intelligence, JELIA'04, is to bring together active researchers interested in all aspects concerning the use of logics in artificial intelligence to discuss current research, results, problems, and applications of both a theoretical and practical nature.
Invited Lecturers: F. Baader, TU Dresden, Germany; B. Nebel, Univ. Freiburg, Germany; F. Rossi, Univ. of Padova, Italy.
Information: Send your questions and comments to email: `jelia04@di.fct.unl.pt` or `http://centria.di.fct.unl.pt/~jelia2004`.

*27–October 1 **IMA Workshop: Modeling of Soft Matter**, University of Minnesota, Minneapolis, Minnesota.
Organizers: M.-C. Calderer (UMN), E. Terentjev (Univ. of Cambridge).
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/fall/softmatter.html`.

27–October 2 **Workshop on Elliptic Cohomology and Its Relation to the Geometry of Loop Spaces**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 460)

27–October 2 **Workshop on Elliptic Cohomology and Its Relation to the Geometry of Loop Spaces**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 460)

28–October 1 **48th Annual Conference of the Australian Mathematical Society**, RMIT University, Melbourne, Australia. (Apr. 2004, p. 460)

October 2004

*6–9 **HYKE Conference on Complex Flows**, Centre de Recerca Matemàtica, Bellaterra, Italy.
Organizer: Centre de Recerca Matemàtica.
Aim: The main objective of the conference is to highlight new developments of either a numerical or analytical nature in kinetic and hydrodynamic equations. We would like to foster the interaction with applications, with special sessions devoted to two applications: granular media and astrophysical flows.
Speakers: E. Caglioti (Univ. di Roma I, Italy), B. Despres (Univ. Paris VI, France), L. Desvilletes (ENS Cachan, France), F. Filbet (Univ. d'Orléans, France), J. A. Font (Univ. de Valencia, Spain), A. Goldshtein (Technion Haifa, Israel), L. Gosse (IAC Bari, Italy), T. Goudon (Univ. des Sci. et Tech. Lille 1, France), C. Helzel (IAM Bonn, Germany), J. M. Ibáñez (Univ. de Valencia, Spain), P. E. Jabin (ENS Paris, France), K. H. Karlsen (Univ. of Bergen, Norway), D. Levermore (Univ. of Maryland), A. Mangeney (Inst. de Phys. du Globe de Paris, France), J. M. Marti (Univ. de Valencia, Spain), C. Mouhot (ENS Lyons, France), S. Osher (UCLA), T. Poeschel (Humboldt-Univ.-Charité, Germany), S. Rjasanow (Saarland Univ., Germany), G. Russo (Univ. di Catania, Italy), O. Sánchez (Univ. de Granada, Spain), A. Santos (Univ. de Extremadura, Spain), H. J. Schroll (Lund Univ., Sweden), S. Serna (Univ. de Valencia, Spain), B. Sjogreen (KTH Stockholm, Sweden), M. Torrillhon (ETHZ, Switzerland), G. Toscani (Univ. di Pavia, Italy), J. J. L. Velázquez (Univ. Complutense de Madrid, Spain).
Deadlines: Application for financial support: June 5, 2004. Title of presentation: June 6, 2004. Registration and payment: June 30, 2004.
Information: `http://www.crm.es/ComplexFlows`; email: `ComplexFlows@crm.es`.

*6–12 **Workshop "Global and Geometric Aspects in Nonlinear PDE"**, Yerevan State University, Yerevan, Armenia.
Scientific Committee: L. Caffarelli, P. Markowich, H. Shahgholian.
Organizing Committee: A. Hakobyan, M. Poghosyan.
Tentative List of Speakers: A. Aftalion (France), I. Athanasopoulos (Greece), H. Berestycki (France), Y. Brenier (France), X. Cabre (Spain), M. Chipot (Switzerland), C. Lederman (Argentina), K. Lee (South Korea), F. Lin (USA), N. Garofalo (USA), F. Hamel (France), R. Monneau (France), L. Nirenberg (USA), S. Osher (USA), S. Salsa (Italy), S. Serfaty (USA), J. Sethian (USA), H. Mete Soner (Turkey), T. Souganidis (USA), N. Trudinger (Australia), N. Uraltseva (Russia), J. Vazquez Suarez (Spain), N. Wolanski (Argentina).
Deadline: June 1, 2004.
Information: `http://math.sci.am`; `http://www.math.kth.se/~henriksh/armenia04.html`; email: `mathconf@ysu.am`.

7–8 **DIMACS Workshop on Computational Issues in Auction Design**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Apr. 2004, p. 460)

*12–15 **3rd WSEAS International Conference on Applied Mathematics and Computer Science (AMCOS 2004)**, Copacabana, Rio de Janeiro, Brazil.
Information: `http://www.wseas.org`.

13–16 **Conference on Automorphic Forms and the Trace Formula, in Honour of James Arthur on the Occasion of His 60th Birthday**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 460)

14–15 **DIMACS Workshop on Cryptography: Theory Meets Practice**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Apr. 2004, p. 460)

*14–15 **Seventh New Mexico Analysis Seminar**, University of New Mexico, Albuquerque, New Mexico.
Description: The New Mexico Analysis Seminar is a yearly conference that runs between the University of New Mexico and New Mexico State University. The goal of the seminar is to provide an opportunity for scientific exchange and cooperation among broadly defined analysts. The centerpieces of the conference this year will be two workshops led by the keynote speakers.
Keynote Speakers: Patricia Bauman, Purdue University, "Analysis of Ginzburg-Landau models with applications to materials"; Luca Capogna, University of Arkansas, "Mean curvature flow in the Heisenberg group and applications".
Lecturers: To complement the workshops, four invited one-hour lectures will be featured: Lia Bronsard (McMaster Univ.), Donatella Danielli (Purdue Univ.), Scott Pauls (Darmouth College), and Peter Sternberg (Indiana Univ.).
Sponsor: NSF.
Organizers: Cristina Pereyra (`crisp@math.unm.edu`), Joseph Lakey (`jlakey@nmsu.edu`), Tiziana Giorgi (`tgiorgi@nmsu.edu`), Adam Sikora (`asikora@nmsu.edu`), Robert Smits (`rsmits@nmsu.edu`).
Information: `http://www.math.unm.edu/colloquia/analysis_seminar.php`.

16–17 **AMS Southeastern Section Meeting**, Vanderbilt University, Nashville, Tennessee. (May 2003, p. 604)

16–17 **AMS Western Section Meeting**, University of New Mexico, Albuquerque, New Mexico. (May 2003, p. 604)

23–24 **AMS Central Section Meeting**, Northwestern University, Evanston, Illinois. (Feb. 2004, p. 279)

24–31 **The Tenth International Conference in Modern Group Analysis (MOGRAN X)**, Larnaca, Cyprus. (Mar. 2004, p. 361)

*25–29 **IMA Workshop: Singularities in Materials**, University of Minnesota, Minneapolis, Minnesota.
Organizers: F. Lin (NYU), J. Rubinstein (Indiana), P. J. Sternberg (Indiana).
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/fall/singularities.html`.

*27-29 **DIMACS/LAMSADE Workshop on Computer Science and Decision Theory**, University Paris Dauphine, France.
Short Description: The workshop focuses on modern computer science applications of methods developed by decision theorists, in particular methods involving consensus and associated order relations. The broad outlines concern connections between computer science and decision theory, development of new decision-theory-based methodologies relevant to the scope of modern CS problems, and investigation of their applications to problems of computer science and also to problems of the social sciences which could benefit from new ideas and techniques. For more details see the DIMACS/LAMSADE partnership.
Main Themes: Preference modelling, social choice, knowledge extraction, fusion of information, issues involving AI, large databases and inference , computational intractability, of consensus functions, axiomatics: approaches and algorithms for consensus functions, order relations and revealed preferences.
Sponsor: DIMACS/LAMSADE PARTNERSHIP, National Science Foundation, and CNRS.
Organizers: Mel Janowitz, DIMACS, email: `melj@dimacs.rutgers.edu`; Fred Roberts, DIMACS, email: `froberts@dimacs.rutgers.edu`; Alexis Tsoukias, LAMSADE, email: `tsoukias@lamsade.dauphine.fr`.
Information: `http://dimacs.rutgers.edu/Workshops/DecisionTheory/`.

27-29 **SEM Fall Conference—MEMS**, Sheraton Springfield Hotel, Springfield, Massachusetts. (May 2004, p. 576)

November 2004

1-4 **ICDM '04: The Fourth IEEE International Conference on Data Mining**, Brighton, United Kingdom. (Mar. 2004, p. 361)

*1-5 **Recent Developments in Spectral Geometry**, Blossin (near Berlin), Germany.
Description: The workshop will be devoted to recent aspects in index, scattering, and spectral theory of geometric operators (Laplace, Dirac) on Riemannian manifolds.
Organizers: C. Bär (Potsdam), Th. Friedrich (Berlin), D. Schüth (Berlin).
Invited Lecturers: W. Ballmann, Bonn; T. Branson, Iowa; U. Bunke, Göttingen; G. Carron, Nantes; J. Dodziuk, New York; R. Mazzeo, Stanford; W. Müller, Bonn; P. Perry, Kentucky; St. Zelditch, Baltimore.
Information: `http://www-irm.mathematik.hu-berlin.de/~pahlisch/Blossin-2004.html`.

*3-5 (NEW DATE) **DIMACS Workshop on Mobile and Wireless Security**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Short Description: The rapid growth of both voice and data wireless communications has resulted in several serious security problems in both the voice and data spaces. Unfortunately, many of the early security mistakes made with wireless voice communications were repeated with data communications. This workshop will focus on addressing the many outstanding issues that remain in wireless cellular and WLAN networking such as (but not limited to): Management and monitoring, ad hoc trust establishment, secure roaming between overlay networks, availability and denial of service mitigation, and network and link layer security protocols. We will seek to extend work on ad hoc networking from a nonadversarial setting, assuming a trusted environment, to a more realistic setting in which an adversary may attempt to disrupt communication. We will investigate a variety of approaches to securing ad hoc networks, in particular ways to take advantage of their inherent redundancy (multiple routes between nodes), replication, and new cryptographic schemes such as threshold cryptography.
Organizer: Bill Arbaugh, University of Maryland, email: `waa@cs.umd.edu`.
Local Arrangements: Maria Mercado, DIMACS Center, email: `mercado@dimacs.rutgers.edu`, 732-445-5928.
Information: `http://dimacs.rutgers.edu/Workshops/MobileWireless/`.

6-7 **AMS Eastern Section Meeting**, University of Pittsburgh, Pittsburgh, Pennsylvania. (Sept. 2003, p. 1009)

7-9 **Constructive Functions Tech-04**, Georgia Institute of Technology, Atlanta, Georgia. (Feb. 2004, p. 1443)

*11-12 **DIMACS Workshop on Markets as Predictive Devices (Information Markets)**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Description: For decades economists have studied an astonishing "side effect" of financial and wagering markets: their ability to serve as highly accurate forecasting devices. This workshop aims to explore the use of markets as a substitute for, or complement to more traditional forecasting tools. We will examine how information flows from traders to the market and back again, how market mechanisms process information, how market prices communicate information and forecasts, and what mechanisms best foster accurate and statistically testable predictions. The workshop will bring together researchers and practitioners from a variety of relevant fields, including economics, finance, computer science, and statistics, in both academia and industry, to discuss the state of the art today and the challenges and prospects for tomorrow.

As part of the workshop, one or more tutorials are planned for the benefit of students and other newcomers to the field; little or no background knowledge will be assumed.
Organizers: R. Hanson, George Mason Univ., email: `rhanson@gmu.edu`; J. Ledyard, Calif. Inst. of Tech., email: `jledyard@hss.caltech.edu`; D. Pennock, Overture Services, email: `David.Pennock@overture.com`.
Local Arrangements: M. Mercado, DIMACS Center, email: `mercado@dimacs.rutgers.edu`, 732-445-5928.
Information: `http://dimacs.rutgers.edu/Workshops/Markets/` .

*15-17 **5th WSEAS International Conference on Acoustics and Music: Theory and Applications (AMTA 2004)**, Tehran, Iran. (Apr. 2004, p. 461)
Other Conferences: Mathematics and Computers in Biology and Chemistry (MCBC'04), Mathematics and Computers in Business and Economics (MCBE'04), Automation & Information (ICAI'04).
Information: `http://www.wseas.org`.

15-17 **Coxeter Lecture Series**, The Fields Institute, Toronto, Ontario, Canada.

*18-20 **IMA Workshop: Future Challenges in Multiscale Modeling and Simulation**, University of Minnesota, Minneapolis, Minnesota.
Organizers: T. Y. Hou (Caltech), M. Luskin (UMN).
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/fall/challenges.html`.

*19-23 **International Conference of Computational Methods in Sciences and Engineering 2004 (ICCMSE 2004)**, Vravrona, Attica, Greece. (Apr. 2004, p. 461)
Description: In the past decades many significant insights have been made in several areas of computational methods in sciences and engineering. New problems and methodologies have appeared. There is permanently a need in these fields for the advancement of information exchange. This undoubtedly beneficial practice of interdisciplinary and multidisciplinary interactions should be expressed by an interdisciplinary and multidisciplinary conference on computational methods in sciences and engineering. ICCMSE 2004 aims to play the above role, and for this reason the aim of the conference is to bring together computational scientists and engineers from several disciplines in order to share methods, methodologies, and ideas.

Information: Secretary ICCMSE 2004 (E. Ralli-Simou), email: `iccmse@uop.gr`; 26 Menelaou Street, Amfithea Paleon Faliron, GR-175 64, Athens, Greece; fax: +30210 94 20 091; `http://www.uop.gr/~iccmse/`.

19–23 **Workshop on Mirror Symmetry**, The Perimeter Institute, Waterloo, Ontario, Canada.

December 2004

5–16 **International Workshop on Nonlinear Partial Differential Equations**, IPM, Tehran, Iran. (Aug. 2003, p. 850)

* 6–10 **III Joint Meeting Japan-Mexico in Topology and Its Applications**, Oaxaca, Mexico.

Description: The purpose of this international meeting is to gather topologists from around the world. All areas of topology will be covered. This is the third in a series of meetings organized by Japanese and Mexican topologists. The first one took place in Morelia, Mexico, in July 1999, and the second one in Matsue, Japan, in June 2002.

The academic program of the conference will consist of 11 plenary lectures, invited talks, and contributed talks. We encourage all participants to present contributed talks in parallel sections.

Organizing Committee: Mexican Committee: Chairman: M. Eudave-Munoz (IMUNAM), D. Juan-Pineda (Algebraic Topology, IMUNAM-Morelia), S. Antonyan (Geometric Topology, Fac. Ciencias, UNAM), V. Nunez (Knot Theory, CIMAT), M. Hrusak (Set-Theory, IMUNAM-Morelia), S. Garcia-Ferreira (Set-Theoretic Topology, IMUNAM-Morelia), and I. Puga (Continuum Theory, Fac. Ciencias, UNAM). Japanese Committee: Chairman: A. Kono (Kyoto Univ.), N. Iwase (Algebraic Topology, Kyushu Univ.), A. Koyama (Geometric Topology, Osaka Kyoiku Univ.), A. Kawauchi (Knot Theory, Osaka City Univ.), S. Kamo (Set-Theory, Osaka Prefecture Univ.) and T. Nogura (Set-Theoretic Topology, Ehime Univ.).

Main Speakers: M. Asaoka (Kyoto Univ.), R. Cauty (Univ. de Paris VI, Pierre et Marie Curie), A. Dranishnikov (Univ. of Florida at Gainesville), J. Gonzalez (CINVESTAV), A. Illanes (IMUNAM), S. Kamada (Hiroshima Univ.), Y. Kamiyama (Ryukyu Univ. of Japan), K. Yamazaki (Tsukuba Univ.), M. Neumann-Coto (IMUNAM), M. G. Tkachenko (Univ. Autonoma Metropolitana-Iz).

Information: `http://www.cimat.mx/~victor/jamex`. There you will be able to register, submit an abstract, and find updated information about the conference; or email: `jamex@matmor.unam.mx`.

* 6–10 **Compact Moduli Spaces and Birational Geometry**, AIM Research Conference Center, Palo Alto, California.

Topics: This workshop, sponsored by AIM and the NSF, will be devoted to the study of compact moduli spaces, especially those inspired by the minimal model program. Perhaps the first example is the Deligne/Mumford compactification of the moduli space of stable curves, where the limiting curves are dictated by the structure of canonical models for surfaces fibered over curves. This was extended to surfaces by Kolár/Shepherd-Barron and Alexeev, which led to work of Corti, Hacking, Tevelev/Keel, Alexeev, and others, where birational geometry inspired the choice of limiting objects and sometimes played a role in constructing moduli spaces.

Goals: The main goals of this workshop are: to promote cross-fertilization by bringing together specialists in birational geometry and moduli theory; to make the techniques of the field more widely known and accessible; and to identify concrete, tractable questions for young researchers entering the area.

Organizers: Brendan Hassett and Sándor Kovács.

Deadline: September 6, 2004.

Information: `http://aimath.org/ARCC/workshops/birational.html`.

13–17 **The 9th Asian Technology Conference in Mathematics (ATCM2004)**, National Institute of Education, Singapore. (Apr. 2004, p. 461)

* 13–17 **Recent Advances in Core Model Theory**, AIM Research Conference Center, Palo Alto, California.

Organizers: John Steel and Ernest Schimmerling.

Topics: This workshop, sponsored by AIM and the NSF, will be devoted to important recent results in core model theory due to Hugh Woodin, results whose proofs are not widely known and have not been published. One of these is Woodin's refutation of the Cofinal Branches Hypothesis (CBH). Another is his identification of HOD computed inside a model of AD+ with a new kind of inner model constructed from extenders and iteration strategies.

Lecturer: Hugh Woodin has agreed to be the primary lecturer. John Steel and possibly one or two others will exposit parts of Hugh Woodin's work or the material on which it rests. We hope that the wider dissemination of these developments will lead to further advances in one of the central programs in pure set theory: extending inner model theory to stronger large cardinal hypotheses.

Deadline: September 13, 2004.

Information: `http://aimath.org/ARCC/workshops/coremodel.html`.

* 13–18 **Joint Conference: The 2004 NZIMA Conference in Combinatorics and Its Applications and The 29th Australasian Conference in Combinatorial Mathematics and Combinatorial Computing (29th ACCMCC)**, Copthornes-Manuels, Lake Taupo, New Zealand.

Topics: Graph Theory, Matroid Theory, Design Theory, Coding Theory, Enumerative Combinatorics, Combinatorial Optimization, Combinatorial Computing and Theoretical Computer Science, Combinatorial Matrix Theory.

Organizing Committee: NZIMA: Paul Bonnington, email: `p.bonnington@auckland.ac.nz`; Geoff Whittle, email: `geoff.whittle@vuw.ac.nz`. ACCMCC: Brendan McKay, email: `bdm@cs.anu.edu.au`; Ian Wanless, email: `imw@cs.anu.edu.au`.

Plenary Speakers: Dan Archdeacon (Univ. of Vermont), Richard Brualdi (Univ. of Wisconsin), Darryn Bryant (Univ. of Queensland), Peter Cameron (Queen Mary, Univ. of London), Bruno Courcelle (Bordeaux Univ.), Catherine Greenhill (Univ. of New South Wales), Bojan Mohar (Univ. of Ljubljana), Bruce Richter (Univ. of Waterloo), Neil Robertson (Ohio State Univ.), Paul Seymour (Princeton Univ.), Robin Thomas (Georgia Inst. of Tech.), Carsten Thomassen (Tech. Univ. of Denmark), Mark Watkins (Univ. of Syracuse), Dominic Welsh (Oxford Univ.).

Registration Deadline: November 14, 2004.

Information: Visit `http://www.nzima.auckland.ac.nz/combinatorics/conference.html`.

* 15–17 **Arithmetic, Geometry and Topology, Conference on the Occasion of Larry Breen's Sixtieth Birthday**, Institut Galilée, Université Paris 13, France.

Information: `http://www-math.univ-paris13.fr/~lb2004/`.

* 16–19 **International Conference on History and Heritage of Mathematical Sciences**, Govt. Model Autonomous Holkar Science College, Indore, India.

Focus: The conference will cover all aspects of the history of mathematical sciences, including mathematics, statistics, operations research, and computer science. In particular the conference will focus on the following areas: General Histories, Source Books and Biographies of Mathematicians; Mathematics and Indigenous Cultures of the World; Ancient Indian Mathematics; Jaina Mathematics; The Origin of Mathematics; Mathematics in 15th to 18th Centuries, Renaissance; 19th and 20th Centuries Mathematics and Mathematical Sciences; History of Mathematics as A Subject in Educational Curricula; Future Prospects. The academic sessions will consist of invited plenary talks and contributed paper presentations.

Organizers: The Indian Society for History of Mathematics; Govt. Model Autonomous Holkar Science College, Indore; Kundakunda Jnanapitha, Indore, and other institutions.

Call for Papers: Papers covering topics pertaining to the above areas are invited for the conference. Authors are requested to submit the full version of their papers in publishable form by October 1, 2004, along with the abstract. The proceedings of the conference will be published.
Information: email: `bsyadav@indianshm.com` (program, talks, papers); email: `anupamjain3@rediffmail.com` or `kundkund@sancharnet.in` (registration, accommodations, etc.).

* 17-19 **4th WSEAS International Conference on Signal Processing, Computational Geometry & Artificial Vision (ISCGAV'04)**, Puerto De La Cruz, Tenerife, Canary Islands, Spain.
Other Conference: Systems Theory and Scientific Computation (ISTASC'04).
Information: `http://www.wseas.org`.

17-19 **International Conference on Smarandache Algebraic Structures**, Indian Institute of Technology, IIT Madras, Chennai, Tamil Nadu, India. (Aug. 2003, p. 850)

17-22 **The Third International Congress of Chinese Mathematicians**, The Chinese Univ. of Hong Kong, Shatin, Hong Kong, P. R. China. (Dec. 2003, p. 1443)

* 18-20 **Recent Advances in Mathematics & Its Applications (ISRAMA 2004)**, Kolkata (Calcutta), India.
Topics: Algebra, Discrete Mathematics & Theoretical Computer Science; Analysis & Topology and their Applications; Geometry and its Applications; Dynamical Systems, Chaos and Fractals; Continuum Mechanics; Plasma Physics; Control Theory and Optimization Theory; Bio-mechanics; Applications of Mathematics to Environmental Problems; History and Philosophy of Physical Science; Quantum Information Theory; Relativity and Its Applications.
Information: Prof. M. R. Adhikari, Secretary, Calcutta Mathematical Society, AE-374, Sector-1, Salt Lake City, India; email: `cms@cal2.vsnl.net.in`.

* 20-23 **Sharp Thresholds for Mixing Times**, AIM Research Conference Center, Palo Alto, California.
Topics: This workshop, sponsored by AIM and the NSF, will address basic questions about the mixing times of Markov chains. The mixing times of Markov chains are fundamental parameters that encode key geometric information about the chain and at the same time have a wide variety of applications. In the last twenty years, computer scientists and probabilists have brought new perspectives and methods to this study. By bringing together experts on a variety of different techniques, we hope that perhaps some of them can be combined or modified to obtain the necessary insights into the problems.
Organizers: Amir Dembo, Yuval Peres, and David Revelle.
Deadline: September 20, 2004.
Information: `http://aimath.org/ARCC/workshops/mixingtimes.html`.

* 29-31 **6th WSEAS International Conference on Mathematical Methods and Computational Techniques in Electrical Engineering (MMACTEE 2004)**, Vouliagmeni, Athens, Greece.
Other Conferences: Nonlinear Analysis, Nonlinear Systems and Chaos (NOLASC 2004), Wavelet Analysis and Multirate Systems (WAMUS 2004).
Information: `http://www.wseas.org`.

January 2005

5-8 **Joint Mathematics Meetings**, Hyatt Regency Atlanta & Atlanta Marriott Marquis, Atlanta, Georgia. (Sept. 2002, p. 1001)

* 7-8 **2004-05 ASL Winter Meeting (with Joint Mathematics Meetings)**, Atlanta, Georgia.
Program Committee: R. Jin, A. Kanamori (chair), and A. Shlapentokh.
Deadline: Abstracts: September 17, 2004 at the ASL Business Office.
Information: email: `asl@vassar.edu`.

8-15 **Geometry: Interactions with Algebra and Analysis**, Napier, New Zealand. (May 2004, p. 576)

* 10-14 **Braid Groups, Clusters and Free Probability**, AIM Research Conference Center, Palo Alto, California.
Topics: This workshop, sponsored by AIM and the NSF, will be devoted to deciphering the mysterious connections between the following objects: Garside monoid structures for Coxeter and braid groups, and the associated "lattices of noncrossing partitions"; the cluster algebras of Fomin and Zelevinsky, and the associated polytopes known as "generalized associahedra"; ad-nilpotent ideals within Borel subalgebras of semisimple Lie algebras or, equivalently, subsets of pairwise incomparable positive roots.
Organizers: Jon McCammond, Alexandru Nica, and Victor Reiner.
Deadline: October 10, 2004.
Information: `http://aimath.org/ARCC/workshops/braidgroups.html`.

10-14 **Workshop on Topological Strings**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 461)

17-July 15 **Model Theory and Applications to Algebra and Analysis**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Apr. 2003, p. 500)

27-29 **IMAC-XXIII Preconference Courses**, Rosen Plaza Hotel, Orlando, Florida. (May 2004, p. 576)

31-February 3 **IMAC-XXIII: A Conference on Structural Dynamics**, Rosen Plaza Hotel, Orlando, Florida. (May 2004, p. 576)

February 2005

* 3-4 (NEW DATE) **DIMACS Workshop on Markets as Predictive Devices (Information Markets)**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Description: For decades economists have studied an astonishing "side effect" of financial and wagering markets: their ability to serve as highly accurate forecasting devices. This workshop aims to explore the use of markets as a substitute for, or complement to, more traditional forecasting tools. We will examine how information flows from traders to the market and back again, how market mechanisms process information, how market prices communicate information and forecasts, and what mechanisms best foster accurate and statistically testable predictions. The workshop will bring together researchers and practitioners from a variety of relevant fields, including economics, finance, computer science, and statistics, in both academia and industry, to discuss the state of the art today and the challenges and prospects for tomorrow. As part of the workshop, one or more tutorials are planned for the benefit of students and other newcomers to the field; little or no background knowledge will be assumed.
Organizers: R. Hanson, George Mason Univ., email: `rhanson@gmu.edu`; J. Ledyard, Calif. Inst. of Tech., email: `jledyard@hss.caltech.edu`; D. Pennock, Overture Services, email: `David.Pennock@overture.com`.
Local Arrangements: M. Mercado, DIMACS Center, email: `mercado@dimacs.rutgers.edu`, 732-445-5928.
Information: `http://dimacs.rutgers.edu/Workshops/Markets/`.

* 7-9 **IMA Tutorial/Workshop: Where Mathematics Meets Industry**, University of Minnesota, Minneapolis, Minnesota.
Organizers: G. Milton (Utah).
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/`.

14-18 **Geometry: Interactions with Algebra and Analysis**, University of Auckland, Auckland, New Zealand. (May 2004, p. 576)

15-17 **International Symposium on Stochastic Models in Reliability, Safety, Security and Logistics (SMRSSL'05),** Negev Academic College of Engineering (NACE), Beer Sheva, Israel. (Apr. 2004, p. 461)

March 2005

*1-2 **DIMACS Short Course: A Field Guide to GenBank and NCBI Molecular Biology Resources,** DIMACS Center, Rutgers University, Piscataway, New Jersey.
Short Description: The National Center for Biotechnology Information (NCBI) presents "A Field Guide to GenBank and NCBI Molecular Biology Resources", a lecture and hands-on computer workshop on GenBank and related databases covering effective use of the Entrez databases and search service, the BLAST similarity search engine, genome data and related resources. Further information about NCBI may be found at `http://www.ncbi.nlm.nih.gov`.
Sponsors: The National Center for Biotechnology Information, the Department of Genetics at Rutgers University, DIMACS, and the BIOMAPS Institute for Quantitative Biology.
Organizers: Paul Ehrlich, BIOMAPS Institute, email: `pehrlich@biomaps.rutgers.edu`; Mel Janowitz, DIMACS, email: `melj@dimacs.rutgers.edu`; Tara Matise, Rutgers University, email: `matise@biology.rutgers.edu`.
Local Arrangements: Maria Mercado, DIMACS Center, email: `mercado@dimacs.rutgers.edu`, 732-445-5928.
Information: `http://dimacs.rutgers.edu/Workshops/NCBI/`.

*7-9 **DIMACS Working Group on Order Theoretic Aspects of Epidemiology,** DIMACS Center, Rutgers University, Piscataway, New Jersey.
Short Description: Many practical epidemiological problems involve the comparison of one or more quantities. Most often the quantities are rates or proportions leading to a measure of effect or association, but they may also involve distances, exposure categories, job titles, etc. Often the actual values in question are not important, only whether one value is smaller than or larger than a second, i.e., their order. This working group will study how fundamental order-theoretic concepts of TCS and DM such as semiorders, interval orders, general partial orders, and lattices can be used to improve the results of epidemiological investigations. We will give epidemiological concepts a careful definition in the language of partial orders and explore the use of visualization of order-theoretic concepts in epidemiologic studies. The latter will involve issues such as how best to visualize a poset through clever presentation of its Hasse diagram, an issue of great interest in the field of TCS known as graph drawing.
Sponsor: DIMACS.
Organizers: David Ozonoff, Boston University, email: `dozonoff@bu.edu`; Melvin Janowitz, Rutgers University, email: `melj@dimacs.rutgers.edu`; Fred Roberts, Rutgers University, email: `froberts@dimacs.rutgers.edu`.
Information: `http://dimacs.rutgers.edu/Workshops/WGOrder/`.

*7-11 **Third International Conference on Pattern Avoiding Permutations,** University of Florida, Gainesville, Florida.
Organizer: Miklos Bona, email: `bona@math.ufl.edu`.
Deadline: For submitting 6-page extended abstracts: December 1, 2004.
Keynote Speaker: Doron Zeilberger (Rutgers University).
Information: email: `bona@math.ufl.edu`.

18-19 **AMS Southeastern Section Meeting,** Western Kentucky University, Bowling Green, Kentucky. (May 2004, p. 576)

*19-22 **2005 ASL Annual Meeting,** Stanford, California.
Program Committee: J. Mitchell, M. Rathjen, S. Shapiro, R. Solomon, P. Speissegger, and J. Steel (chair).
Organizing Committee: A. Arana, S. Feferman, G. Mints, J. Mitchell, and R. Sommer (chair).
Information: email: `asl@vassar.edu`.

21-25 **Workshop on N=1 Compactifications,** The Fields Institute, Toronto, Ontario, Canada. (Mar. 2004, p. 361)

*28-30 **IMA Tutorial/Workshop: New Paradigms in Computation,** University of Minnesota, Minneapolis, Minnesota.
Organizer: R. V. Kohn (NYU).
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/spring/paradigms.html`.

*28-April 1 **Generalized Kostka Polynomials,** AIM Research Conference Center, Palo Alto, California.
Topics: This workshop, sponsored by AIM and the NSF, concerns Kostka polynomials and their connections to various areas of mathematics. Kostka polynomials and their generalizations have arisen in numerous ways, such as in the context of symmetric functions, combinatorics, representation theory, quantum groups and crystal bases, statistical mechanics, algebraic geometry, and Kazhdan-Lusztig theory. The goal of this workshop is to bring together mathematicians who have studied Kostka polynomials from different points of view, state the various connections and open conjectures, and work towards their proofs.
Organizers: M. Kleber, A. Schilling, and M. Vazirani.
Deadline for Applications: January 28, 2005.
Information: `http://aimath.org/ARCC/workshops/kostka.html`.

28-April 1 **Workshop on String Phenomenology,** The Perimeter Institute, Waterloo, Ontario, Canada. (Apr. 2004, p. 461)

April 2005

1-July 8 **Special Semester on "Modern Methods of Time-Frequency Analysis",** Erwin Schroedinger Institute (ESI) for Mathematical Physics, Vienna, Austria. (Apr. 2004, p. 461)

2-3 **AMS Eastern Section Meeting,** University of Delaware, Newark, Delaware. (May 2004, p. 576)

8-10 **AMS Central Section Meeting,** Texas Tech University, Lubbock, Texas. (May 2004, p. 576)

*11-15 **IMA Workshop: Atomic Motion to Macroscopic Models: The Problem of Disparate Temporal and Spatial Scales in Matter,** University of Minnesota, Minneapolis, Minnesota.
Organizers: R. D. James (UMN), M. Luskin (UMN), J. Maddocks (Swiss Fed. Inst. of Tech.), C. Schütte (Freie Univ. Berlin).
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/spring/atomic.html`.

*14-15 **DIMACS Workshop on Intellectual Property Protection,** DIMACS Center, Rutgers University, Piscataway, New Jersey.
Short Description: We have reached the point where there is enough bandwidth on the Internet and enough computing and storage power on client machines that most digital goods can be easily shared and utilized by many. Peer-to-peer networks make it easy for users to find music and other files and to download them from a nearby computer. Existing copyright laws developed to deal with exchanges that are based on physical media or paper are evolving to laws dealing with electronic exchanges, but these laws need to be developed in tandem with new technologies for digital rights management. Technologies for protecting intellectual property have been developed in the research community, but no perfect solution exists. There is need to develop such technologies that reflect both protection of the rights holder and the "public good" resulting from exchange of ideas. This workshop aims to explore the problem of protecting soft goods and managing digital rights. A major goal is to explore the limits of what can be accomplished in software and to consider the minimal hardware required for solutions to work.
Sponsor: DIMACS.

Organizers: D. Dean, SRI Internat., email: `ddean@csl.sri.com`; M. Jakobsson, RSA Labs, email: `mjakobsson@rsasecurity.com`.
Information: `http://dimacs.rutgers.edu/Workshops/Intellectual/`.

16-17 **AMS Western Section Meeting**, University of California, Santa Barbara, California. (May 2004, p. 576)

May 2005

*2-6 **IMA Workshop: Experiments in Physical Biology, Part I**, University of Minnesota, Minneapolis, Minnesota.
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/spring/biology.html`.

2-6 **Workshop on Gravitational Aspects of String Theory**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 461)

*6-9 **Statistical Inferences on Shape Manifolds**, AIM Research Conference Center, Palo Alto, California.
Topics: This workshop, sponsored by AIM and the NSF, will be devoted to algorithmic and computational shape analysis. It will bring together researchers in the field of shape analysis to identify and discuss outstanding issues in algorithmic shape representation, statistical inferences on shape manifolds, and applications to areas such as medical imaging, homeland security, and military target recognition. Algorithmic shape analysis has a multidisciplinary nature, so the workshop will seek to promote interaction and foster the development of new collaborations among researchers with expertise in mathematics, statistics, and image analysis.
Deadline: February 6, 2005.
Information: Visit `http://aimath.org/ARCC/workshops/shapemanifolds.html`.

*15-21 **ICMI Study 15: The Professional Education and Development of Teachers of Mathematics**, Águas de Lindóia, São Paulo, Brazil.
Scope and Purpose: The premise of this study, the fifteenth to be organized by the International Commission on Mathematical Instruction (ICMI), is that the education and continued development of teachers is key to students' opportunities to learn mathematics. What teachers of mathematics know, care about, and do is a product of their experiences and socialization, both prior to and after entering teaching, together with the impact of their professional education. The study focuses on the initial and continuing education of teachers of mathematics at the primary and secondary levels. It is organized in two main strands: Teacher Preparation Programs and the Early Years of Teaching; and Professional Learning for and in Practice. The study conference will be a working meeting, where every participant will be expected to be active, and participation is by invitation only, based on submitted proposals. The Program Committee welcomes contributions from individuals from a variety of backgrounds, including mathematicians, teacher educators, and school practitioners.
Program Committee: Deborah Loewenberg Ball, email: `dball@umich.edu` (USA), and Ruhama Even, email: `ruhama.even@weizmann.ac.il` (Israel), cochairs; Romulo Lins, email: `romlins@rc.unesp.br` (Brazil), chair; Jo Boaler (USA), Chris Breen (South Africa), Frédéric Gourdeau (Canada), Marja van den Heuvel-Panhuizen (Netherlands), Barbara Jaworski (Norway), Gilah Leder (Australia), Shiqi Li (China), João Filipe Matos (Portugal), Hiroshi Murata (Japan), Jarmila Novotna (Czech Republic), Aline Robert (France), Bernard R. Hodgson (Canada), and Hyman Bass (USA), ex officio, ICMI Executive Committee.
Deadline for Submissions: October 15, 2004.
Information: `http://www-personal.umich.edu/~dball/icmistudy15.html`.

*16-20 **IMA Workshop: Experiments in Physical Biology, Part II**, University of Minnesota, Minneapolis, Minnesota.
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/spring/biology.html`.

*17-20 **Graph Theory with Altitude**, University of Colorado at Denver, Denver, Colorado.
Description: Graph theory conference in honor of Joan P. Hutchinson on the occasion of her 60th birthday.
Topics: Chromatic and topological graph theory, visibility graphs, graph algorithms, and combinatorics.
Organizers: Ellen Gethner, Mike Jacobson, Arta Doci, and John Clark.
Plenary Speakers: Mike Albertson, Fan Chung, Ron Graham, Carsten Thomassen, Doug West, Sue Whitesides, and Herb Wilf.
Information: `http://carbon.cudenver.edu/~egethner/JoanHutchinson60.html`.

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

June 2005

*6-10 **Moduli Spaces of Properly Embedded Minimal Surfaces**, AIM Research Conference Center, Palo Alto, California.
Topics: This workshop, sponsored by AIM and the NSF, will be devoted to advancing the understanding of properly embedded minimal surfaces in three-space, a subject whose roots go back to Euler and Lagrange. New examples discovered in an explosion of activity in the 1980s have gradually focused the subject on the problem of classification. Recently, several new approaches and techniques have been developed which together begin to suggest that it might be possible to organize these examples into families and indeed to describe the structure of the space of properly embedded minimal surfaces. This workshop will be tightly focused on a few specific questions which are fundamental for this classification effort. These problems are linked to a confluence of attention from mathematicians with different points of view and by the prospect that real progress might be made by approaches using several different methods simultaneously.
Organizers: Michael Wolf, David Hoffman, and Matthias Weber.
Deadline: March 6, 2005 .
Information: Visit `http://aimath.org/ARCC/workshops/minimalsurfaces.html`.

*8-11 **IMA Workshop: Effective Theories for Materials and Macromolecules**, University of Minnesota, Minneapolis, Minnesota.
Organizers: Weinan E (Princeton), R. D. James (UMN), R. V. Kohn (NYU), C. Le Bris (ENPC), M. Luskin (UMN).
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/matter/spring/theories.html`.

*20-25 **Asymptotic and Probabilistic Methods in Geometric Group Theory**, Geneva, Switzerland.
Organizers: Goulnara N. Arzhantseva, Laurent Bartholdi, Alexander Yu. Ol'shanskii, Mark Sapir, and Efim Zelmanov.
Invited Speakers: Werner Ballmann (RFWU, Bonn), Mladen Bestvina (Utah), Marc Burger (ETH, Zürich), Peter Buser (EPFL, Lausanne), Jim Cannon (Utah), Mikhael Gromov (IHES, Paris), Pierre de la Harpe (Geneva), David Kazhdan (HUJI, Jerusalem), Alex Lubotzky (HUJI, Jerusalem) Grigori Margulis (Yale), Shahar Mozes (HUJI, Jerusalem).
Information: `http://mad.epfl.ch/apg/`.

*20-August 15 **Computational Prospects of Infinity**, Institute for Mathematical Sciences, National University of Singapore, Singapore.

Program: This two-month program will focus on recent developments in set theory and recursion theory, which are two main branches of mathematical logic. Topics for set theory will include issues related to Cantor's Continuum Hypothesis (CH), with special attention paid to the importance of the conjecture, while topics for recursion theory will include recursive enumerability and randomness.
Organizing Committee: Cochairs: Chi Tat Chong (National Univ. of Singapore), Qi Feng (National Univ. of Singapore and Chinese Acad. of Sci., China), Theodore A. Slaman (Univ. of California at Berkeley), and W. Hugh Woodin (Univ. of California at Berkeley).
Activities: The program will consist of two tutorials and seminars. The tutorials will provide background material on topics such as Ω-logic, fine structure, recursive enumerability, and effective randomness. Seminars on recent and up-to-date results related to the core themes of the programs will also be conducted.
Registration: Registration forms for participation in the tutorials are available at `http://www.ims.nus.edu.sg/Programs/infinity/index.htm`. Completed forms should be received by the institute at least one month before commencement of each activity. Registration is free of charge. Institute membership is not required for participation.
Information: For general enquiries, please email `ims@nus.edu.sg`, while for enquiries on scientific aspects of the program, please email Qi Feng at `matfq@nus.edu.sg`. More information about the program is available at `http://www.ims.nus.edu.sg/Programs/infinity/index.htm`.

*26–July 1 **ERLOGOL-2005: Intermediate Problems of Model Theory and Universal Algebra**, State Technical University/Mathematics Institute, Novosibirsk, Russia.
Organizers: Algebra department of Novosibirsk State Technical University and Mathematics Institute of Russian Academy of Sciences.
Information: Information about previous meetings is on the following sites: 1995–2001: `http://www2.nstu.ru/deps/algebra/erlogol/`; 2003: `http://www.nstu.ru/science/conf/erlogol-2003`. Pay attention to the `http://www2` in the first address! You may send email to: `algebra@nstu.ru`, `ponom@online.sinor.ru`, `knp1958@yahoo.com`.

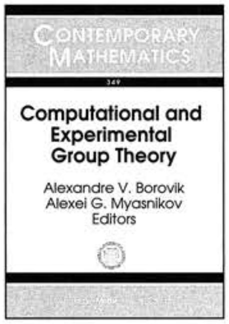
July 2005

*2–7 **SRTL-4: The Fourth International Research Forum on Statistical Reasoning, Thinking, and Literacy**, The University of Auckland, Auckland, New Zealand.
Theme: Reasoning about Distribution.
Deadline: Submission of Interest deadline: June 1, 2004.
Information: Maxine Pfannkuch, Department of Statistics, The University of Auckland, New Zealand; phone: 64 9 373 7599; ext. 88794; fax: 64 9 373 7018; email: `m.pfannkuch@auckland.ac.nz`; or see `http://www.stat.auckland.ac.nz/srtl4/`.

*25–29 **IMA Workshop: Mixed Integer Programming**, University of Minnesota, Minneapolis, Minnesota.
Organizers: A. Atamturk (Berkeley), D. Bienstock (Columbia), S. Dash (IBM), A. Letchford (Lancaster Univ.), J. Linderoth (Lehigh Univ.).
Information: Contact: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St., SE, 400 Lind Hall, Minneapolis, MN 55455; tel: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/hot-topics/2005/W7.25-29.05.html`.

New Publications Offered by the AMS

Algebra and Algebraic Geometry



Computational and Experimental Group Theory

Alexandre V. Borovik, *University of Manchester Institute of Science and Technology, United Kingdom*, and **Alexei G. Myasnikov**, *City University of New York, New York*, Editors

Since its origin in the early 20th century, combinatorial group theory has been primarily concerned with algorithms for solving particular problems on groups given by generators and relations: word problems, conjugacy problems, isomorphism problems, etc. Recent years have seen the focus of algorithmic group theory shift from the decidability/undecidability type of result to the complexity of algorithms. Papers in this volume reflect that paradigm shift.

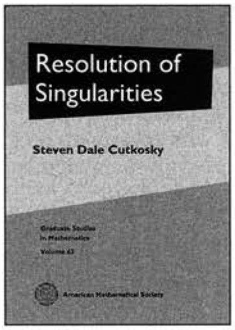
Articles are based on the AMS/ASL Joint Special Session, Interactions Between Logic, Group Theory and Computer Science.

The volume is suitable for graduate students and research mathematicians interested in computational problems of group theory.

Contents: M. Batty, **S. L. Braunstein**, **A. J. Duncan**, and **S. Rees**, Quantum algorithms in group theory; **R. F. Booth**, **D. Y. Bormotov**, and **A. V. Borovik**, Genetic algorithms and equations in free groups and semigroups; **R. H. Gilman** and **A. G. Myasnikov**, One variable equations in free groups via context free languages; **A. D. Miasnikov** and **A. G. Myasnikov**, Whitehead method and genetic algorithms; **B. Khan**, The structure of automorphic conjugacy in the free group of rank two; **R. M. Haralick**, **A. D. Miasnikov**, and **A. G. Myasnikov**, Pattern recognition approaches to solving combinatorial problems in free groups; **D. Y. Bormotov**, Experimenting with primitive elements in F_2.

Contemporary Mathematics, Volume 349

June 2004, 224 pages, Softcover, ISBN 0-8218-3483-5, LC 2004046351, 2000 *Mathematics Subject Classification*: 20B40, 20E05, 20F28, 81P68; 68Q05, 68Q17, 68Q42, 68Q45, 68T05, **All AMS members $55**, List $69, Order code CONM/349N


Resolution of Singularities
Steven Dale Cutkosky
Graduate Studies in Mathematics
Volume 63
American Mathematical Society

Resolution of Singularities

For Classroom Use

Steven Dale Cutkosky, *University of Missouri, Columbia*

The notion of singularity is basic to mathematics. In algebraic geometry, the resolution of singularities by simple algebraic mappings is truly a fundamental problem. It has a complete solution in characteristic zero and partial solutions in arbitrary characteristic.

The resolution of singularities in characteristic zero is a key result used in many subjects besides algebraic geometry, such as differential equations, dynamical systems, number theory, the theory of $\mathcal{D}$-modules, topology, and mathematical physics.

This book is a rigorous, but instructional, look at resolutions. A simplified proof, based on canonical resolutions, is given for characteristic zero. There are several proofs given for resolution of curves and surfaces in characteristic zero and arbitrary characteristic.

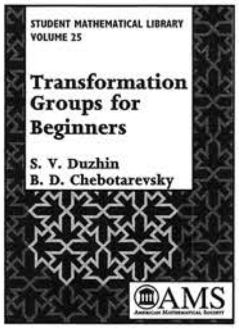
Besides explaining the tools needed for understanding resolutions, Cutkosky explains the history and ideas, providing valuable insight and intuition for the novice (or expert). There are many examples and exercises throughout the text.

The book is suitable for a second course on an exciting topic in algebraic geometry. A core course on resolutions is contained in Chapters 2 through 6. Additional topics are covered in the final chapters. The prerequisite is a course covering the basic notions of schemes and sheaves.

Contents: Introduction; Non-singularity and resolution of singularities; Curve singularities; Resolution type theorems; Surface singularities; Resolution of singularities in characteristic zero; Resolution of surfaces in positive characteristic; Local uniformization and resolution of surfaces; Ramification of valuations and simultaneous resolution; Smoothness and non-singularity; Bibliography; Index.

Graduate Studies in Mathematics, Volume 63

June 2004, 186 pages, Hardcover, ISBN 0-8218-3555-6, LC 2004046123, 2000 *Mathematics Subject Classification*: 13Hxx, 14B05, 14J17, 14E15, 32Sxx, **All AMS members $31**, List $39, Order code GSM/63N


STUDENT MATHEMATICAL LIBRARY VOLUME 25
Transformation Groups for Beginners
S. V. Duzhin
B. D. Chebotarevsky
AMS

Transformation Groups for Beginners

S. V. Duzhin, *Steklov Institute of Mathematics, St. Petersburg, Russia*, and **B. D. Chebotarevsky**, *Minsk, Belarus*

The notion of symmetry is important in many disciplines, including physics, art, and music. The modern mathematical way of treating symmetry is through *transformation groups*. This book offers an easy introduction to these ideas for the relative novice, such as undergraduates in mathematics or even advanced undergraduates in physics and chemistry.

The first two chapters provide a warm-up to the material with, for example, a discussion of algebraic operations on points in the plane and rigid motions in the Euclidean plane. The notions of a transformation group and of an abstract group are then introduced. Group actions, orbits, and invariants are covered in the next chapter. The final chapter gives an elementary exposition of the basic ideas of Sophus Lie about symmetries of differential equations.

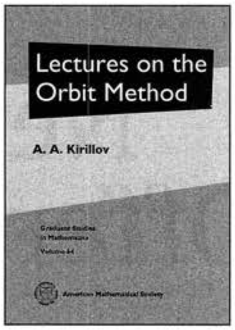
Throughout the text, examples are drawn from many different areas of mathematics. Plenty of figures are included, and many exercises with hints and solutions will help readers master the material.

This item will also be of interest to those working in geometry and topology.

Contents: Algebra of points; Plane movements; Transformation groups; Arbitrary groups; Orbits and ornaments; Other types of transformations; Symmetries of differential equations; Answers, hints and solutions to exercises; Index.

Student Mathematical Library, Volume 25

July 2004, approximately 256 pages, Softcover, ISBN 0-8218-3643-9, LC 2004049676, 2000 *Mathematics Subject Classification*: 22-01, 54H15, **All AMS members $31**, List $39, Order code STML/25N


Lectures on the Orbit Method
A. A. Kirillov

Lectures on the Orbit Method

For Classroom Use

A. A. Kirillov, *University of Pennsylvania, Philadelphia*

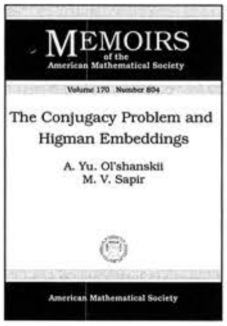
Isaac Newton encrypted his discoveries in analysis in the form of an anagram that deciphers to the sentence, "It is worthwhile to solve differential equations". Accordingly, one can express the main idea behind the orbit method by saying "It is worthwhile to study coadjoint orbits".

The orbit method was introduced by the author, A. A. Kirillov, in the 1960s and remains a useful and powerful tool in areas such as Lie theory, group representations, integrable systems, complex and symplectic geometry, and mathematical physics. This book describes the essence of the orbit method for non-experts and gives the first systematic, detailed, and self-contained exposition of the method. It starts with a convenient "User's Guide" and contains numerous examples. It can be used as a text for a graduate course, as well as a handbook for non-experts and a reference book for research mathematicians and mathematical physicists.

Contents: Geometry of coadjoint orbits; Representations and orbits of the Heisenberg group; The orbit method for nilpotent Lie groups; Solvable Lie groups; Compact Lie groups; Miscellaneous; Abstract nonsense; Smooth manifolds; Lie groups and homogeneous manifolds; Elements of functional analysis; Representation theory; References; Index.

Graduate Studies in Mathematics, Volume 64

August 2004, approximately 432 pages, Hardcover, ISBN 0-8218-3530-0, LC 2004047940, 2000 *Mathematics Subject Classification*: 22-02, **All AMS members $52**, List $65, Order code GSM/64N


MEMOIRS of the American Mathematical Society
Volume 170 Number 804
The Conjugacy Problem and Higman Embeddings
A. Yu. Ol'shanskii
M. V. Sapir
American Mathematical Society

The Conjugacy Problem and Higman Embeddings

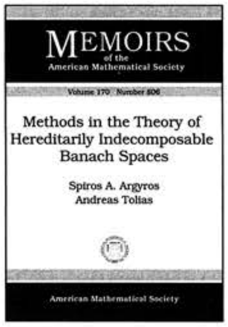
A. Yu. Ol'shanskii, *Moscow State University*, and **M. V. Sapir**, *Vanderbilt University, Nashville, TN*

Contents: Introduction; List of relations; The first properties of $\mathcal{H}$; The group $\mathcal{H}_2$; The word problem in $\mathcal{H}_1$; Some special diagrams; Computations of $S \cup \bar{S}$; Spirals; Rolls; Arrangement of hubs; The end of the proof; References; Subject index.

Memoirs of the American Mathematical Society, Volume 170, Number 804

July 2004, 133 pages, Softcover, ISBN 0-8218-3513-0, LC 2004046105, 2000 *Mathematics Subject Classification*: 20E07, 20F06, 20F10, **Individual member $35**, List $58, Institutional member $46, Order code MEMO/170/804N

Analysis



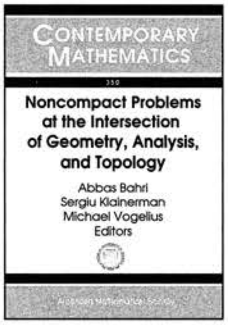
Methods in the Theory of Hereditarily Indecomposable Banach Spaces

Spiros A. Argyros, *National Technical University of Athens*, and **Andreas Tolias**, *Max Planck Institute, Tubingen, Germany*

Contents: Introduction; General results about H.I. spaces; Schreier families and repeated averages; The space $X = T[G, (S_{n_j}, \frac{1}{m_j})_j, D]$ and the auxiliary space T_{ad}; The basic inequality; Special convex combinations in X; Rapidly increasing sequences; Defining D to obtain a H.I. space X_G; The predual $(X_G)_*$ of X_G is also H.I.; The structure of the space of operators $\mathcal{L}(X_G)$; Defining G to obtain a nonseparable H.I. space X_G^*; Complemented embedding of $\ell^p, 1 \leq p < \infty$, in the duals of H.I. spaces; Compact families in $\mathbb{N}$; The space $X_G = T[G, (S_{\xi_j}, \frac{1}{m_j})_j, D]$ for an S_ξ bounded set G; Quotients of H.I. spaces; Bibliography.

Memoirs of the American Mathematical Society, Volume 170, Number 806

July 2004, 114 pages, Softcover, ISBN 0-8218-3521-1, LC 2004046103, 2000 *Mathematics Subject Classification*: 46B20, 46B26, 46B03, **Individual member $33**, List $55, Institutional member $44, Order code MEMO/170/806N



Noncompact Problems at the Intersection of Geometry, Analysis, and Topology

Abbas Bahri, *Rutgers University, New Brunswick, NJ*, **Sergiu Klainerman**, *Princeton University, NJ*, and **Michael Vogelius**, *Rutgers University, New Brunswick, NJ*, Editors

This proceedings volume contains articles from the conference held at Rutgers University in honor of Haim Brezis and Felix Browder, two mathematicians who have had a profound impact on partial differential equations, functional analysis, and geometry.

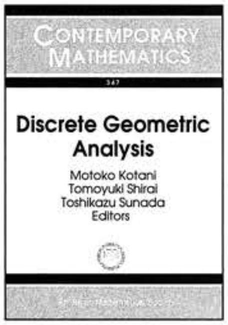
Mathematicians attending the conference had interests in noncompact variational problems, pseudo-holomorphic curves, singular and smooth solutions to problems admitting a conformal (or some group) invariance, Sobolev spaces on manifolds, and configuration spaces. One day of the proceedings was devoted to Einstein equations and related topics. Contributors to the volume include, among others, Sun-Yung A. Chang, Luis A. Caffarelli, Carlos E. Kenig, and Gang Tian.

The material is suitable for graduate students and researchers interested in problems in analysis and differential equations on noncompact manifolds.

Contents: **M. O. Ahmedou**, Conformal deformations of Riemannian metrics via "critical point theory at infinity": The conformally flat case with umbilic boundary; **H. Bahouri** and **J.-Y. Chemin**, Cubic quasilinear wave equation and bilinear estimates; **F. Bethuel** and **G. Orlandi**, Ginzburg-Landau functionals, phase transitions and vorticity; **S.-Y. A. Chang**, **J. Qing**, and **P. Yang**, On the topology of conformally compact Einstein 4-manifolds; **F. R. Cohen**, On loop spaces of configuration spaces, and related spaces; **L. A. Caffarelli**, **D. Jerison**, and **C. E. Kenig**, Global energy minimizers for free boundary problems and full regularity in three dimensions; **M. Dafermos**, Stability and instability of the Reissner-Nordström Cauchy horizon and the problem of uniqueness in general relativity; **E. Hebey**, Nonlinear elliptic equations of critical Sobolev growth from a dynamical viewpoint; **F. Hélein**, Hamiltonian formalisms for multidimensional calculus of variations and perturbation theory; **F. H. Lin**, Revisit the topology of Sobolev maps; **Y. Martel** and **F. Merle**, Review on blow up and asymptotic dynamics for critical and subcritical gKdV equations; **R. Mazzeo**, Recent advances in the global theory of constant mean curvature surfaces; **P. Mironescu**, On some properties of S^1-valued fractional Sobolev spaces; **P. H. Rabinowitz**, Homoclinics for a semilinear elliptic PDE; **S. Serfaty** and **E. Sandier**, Vortices for Ginzburg-Landau equations: With magnetic field versus without; **G. Tian**, Some regularity problems of stationary harmonic maps.

Contemporary Mathematics, Volume 350

July 2004, 252 pages, Softcover, ISBN 0-8218-3635-8, LC 2004047646, 2000 *Mathematics Subject Classification*: 58-06, 53-06, **All AMS members $55**, List $69, Order code CONM/350N



Discrete Geometric Analysis

Motoko Kotani, *Tohoku University, Sendai, Japan*, **Tomoyuki Shirai**, *Kanazawa University, Japan*, and **Toshikazu Sunada**, *Tohoku University, Sendai, Japan*, Editors

This book is a collection of papers from the proceedings of the first symposium of the Japan Association for Mathematical Sciences. Topics covered center around problems of geometric analysis in relation to heat kernels, random walks, and Poisson boundaries on discrete groups, graphs, and other combinatorial objects.

The material is suitable for graduate students and research mathematicians interested in heat kernels and random works on groups and graphs.

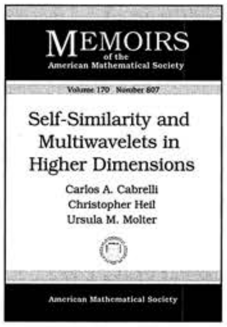
This item will also be of interest to those working in probability.

Contents: **N. Lohoué** and **G. Alexopoulos**, On the asymptotic behavior of convolution powers and heat kernels on Lie groups; **Y. Higuchi** and **T. Shirai**, Some spectral and geometric properties for infinite graphs; **S. Ishiwata**, Asymptotic behavior of a transition probability for a random walk on a nilpotent covering graph; **M. Izumi**, Non-commutative Poisson boundaries; **V. A. Kaimanovich**, Boundary amenability of hyperbolic spaces; **T. Kato**, Spectral analysis on tree like spaces from gauge theoretic view points; **S. Kojima** and **S. Mizushima**, The Dehn filling space of a certain hyperbolic 3-orbifold; **M. Kotani**, An asymptotic of the large deviation for random walks on a crystal lattice; **B. M. Hambly** and **T. Kumagai**, Heat kernel estimates and law of the iterated logarithm for symmetric random walks on fractal graphs; **A. Lubotzky** and **Y. Shalom**, Finite representations in the unitary dual and Ramanujan groups; **N. Monod**, Stabilization for SL_n in bounded cohomology; **H. Nagoshi**, Spectral theory of certain arithmetic graphs; **A. Nevo**, Radial geometric analysis on groups; **H. Urakawa**, The heat kernel and the Green kernel of an infinite graph.

Contemporary Mathematics, Volume 347

July 2004, approximately 273 pages, Softcover, ISBN 0-8218-3351-0, LC 2004041141, 2000 *Mathematics Subject Classification*: 20-06, 60-06, 37-06, 52-06; 52Cxx, 37Axx, **All AMS members $55**, List $69, Order code CONM/347N

Applications



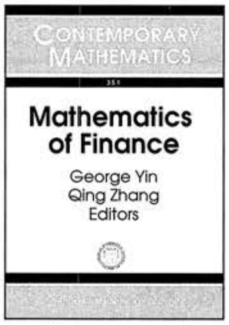
Self-Similarity and Multiwavelets in Higher Dimensions

Carlos A. Cabrelli, *University of Buenos Aires, Argentina*, **Christopher Heil**, *Georgia Institute of Technology, Atlanta*, and **Ursula M. Molter**, *University of Buenos Aires, Argentina*

Contents: Introduction; Matrices, tiles, and the joint spectral radius; Generalized self-similarity and the refinement equation; Multiresolution anaylsis; Examples; Bibliography; Appendix A. Index of symbols.

Memoirs of the American Mathematical Society, Volume 170, Number 807

July 2004, 82 pages, Softcover, ISBN 0-8218-3520-3, LC 2004046102, 2000 *Mathematics Subject Classification*: 39A10; 39B62, **Individual member $31**, List $51, Institutional member $41, Order code MEMO/170/807N



Mathematics of Finance

George Yin, *Wayne State University, Detroit, MI*, and **Qing Zhang**, *University of Georgia, Athens*, Editors

The mathematics of finance involves a wide spectrum of techniques that go beyond traditional applied mathematics. The field has witnessed a tremendous amount of progress in recent years, which has inspired communication and networking among researchers in finance, economics, engineering, and industry. This volume contains papers based on talks given at the first AMS-IMS-SIAM Joint Summer Research Conference on Mathematics of Finance held at Snowbird (UT).

Topics covered here include modeling, estimation, optimization, control, risk assessment and management, contingent claim pricing, dynamic hedging, and financial derivative design. The book is suitable for graduate students and research mathematicians interested in mathematical finance.

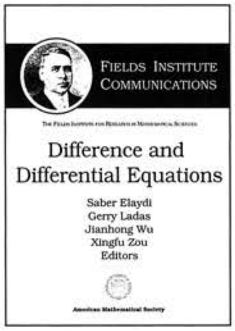
This item will also be of interest to those working in probability.

Contents: **C. Albanese** and **O. X. Chen**, Credit barrier models in a discrete framework; **P. Barrieu** and **N. El Karoui**, Optimal derivatives design under dynamic risk measures; **J. Bialkowski** and **J. Jakubowski**, On pricing of forward and futures contracts on zero-coupon bonds in the Cox-Ingersoll-Ross model; **T. R. Bielecki**, **M. Jeanblanc**, and **M. Rutkowski**, Pricing and hedging of credit risk: Replication and mean-variance approaches (I); **T. R. Bielecki**, **M. Jeanblanc**, and **M. Rutkowski**, Pricing and Hedging of credit risk: Replication and mean-variance approaches (II); **R. Carmona** and **M. Ludkovski**, Spot convenience yield models for the energy markets; **N. Castañeda-Leyva** and **D. Hernández-Hernández**, Optimal portfolio management with consumption; **T. E. Duncan**, Some processes associated with a fractional Brownian motion; **R. J. Elliott** and **J. van der Hoek**, Pricing claims on non tradable assets; **W. H. Fleming**, Some optimal investment, production and consumption models; **J.-P. Fouque** and **C.-H. Han**, Asian options under multiscale stochastic volatility; **X. Guo**, A regime switching model: Statistical estimation, empirical evidence, and change point detection; **F. B. Hanson**, **J. J. Westman**, and **Z. Zhu**, Multinomial maximum likelihood estimation of market parameters for stock jump-diffusion models; **U. G. Haussmann** and **J. Sass**, Optimal terminal wealth under partial information for HMM stock returns; **K. Helmes**, Computing optimal selling rules for stocks using linear programming; **Y. Hu**, Optimization of consumption and portfolio and minimization of volatility; **M. Jonsson** and **R. Sircar**, Options: To buy or not to buy?; **H. Kaise** and **S. J. Sheu**, Risk sensitive optimal investment: Solutions of the dynamical programming equation; **A. E. B. Lim**, Hedging default risk in an incomplete market; **A. E. B. Lim** and **X. Y. Zhou**, Mean-variance portfolio choice with discontinuous asset prices and nonnegative wealth processes; **M. Musiela** and **T. Zariphopoulou**, Indifference prices of early exercise claims; **B. Pasik-Duncan**, Random walk around some problems in identification and stochastic adaptive control with applications to finance; **E. Platen**, Pricing and Hedging for incomplete jump diffusion benchmark models; **L. C. G. Rogers**, Why is the effect of proportional transaction costs $O(\delta^{2/3})$?; **W. J. Runggaldier**, Estimation via stochastic filtering in financial market models; **J. L. Stein**, Stochastic optimal control modeling of debt crises; **L. Stettner**, Duality and risk sensitive portfolio optimization; **R. H. Stockbridge**, Characterizing option prices by linear programs; **J. W. Wang** and **Q. Zhang**, Pricing defaultable bond with regime switching; **S. Wu** and **Y. Zeng**, Affine regime-switching models for interest rate term structure; **G. Yin** and **Q. Zhang**, Stochastic approximation methods for some finance problems.

Contemporary Mathematics, Volume 351

July 2004, 398 pages, Softcover, ISBN 0-8218-3412-6, LC 2004046167, 2000 *Mathematics Subject Classification*: 91B16, 91B26, 91B28, 60G15, 60G40, 60J10, 60J60, 93E20, **All AMS members $79**, List $99, Order code CONM/351N

Differential Equations


Fields Institute Communications
Difference and Differential Equations
Saber Elaydi
Gerry Ladas
Jianhong Wu
Xingfu Zou
Editors

Difference and Differential Equations

Saber Elaydi, *Trinity University, San Antonio, TX*, **Gerry Ladas**, *University of Rhode Island, Kingston*, **Jianhong Wu**, *York University, North York, ON, Canada*, and **Xingfu Zou**, *Memorial University of Newfoundland, St. John's, Canada*, Editors

This volume contains papers from the 7th International Conference on Difference Equations held at Hunan University (Changsa, China), a satellite conference of ICM2002 Beijing. The volume captures the spirit of the meeting and includes peer-reviewed survey papers, research papers, and open problems and conjectures.

Articles cover stability, oscillation, chaos, symmetries, boundary value problems and bifurcations for discrete dynamical systems, difference-differential equations, and discretization of continuous systems.

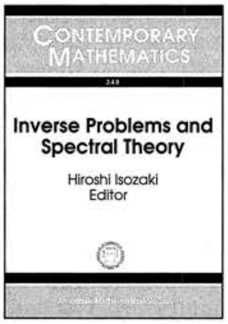
The book presents state-of-the-art research in these important areas. It is suitable for graduate students and researchers in difference equations and related topics.

This item will also be of interest to those working in applications.

Contents: *Survey articles:* **H. Brunner**, The discretization of Volterra functional integral equations with proportional delays; **J. M. Cushing**, The LPA model; **X. Z. Qian** and **Z. C. Wang**, A survey on oscillation of linear delay difference equations; **Y. Yi**, On almost automorphic oscillations; *Research articles:* **R. M. Abu-Saris** and **K. I. Al-Dosary**, Complex exponential Vandermonde determinant with application to discrete boundary value problem; **Y. Cao**, A convergence theorem related to iterative mean clustering; **A. Chen** and **L. Huang**, Global attractivity in a model of bobwhite quail with delay; **S. S. Cheng**, **C.-W. Chen**, and **T. Y. Wu**, Linear time discrete periodic diffusion networks; **B. Dai**, **X. Qian**, and **L. Huang**, Convergence of solutions for a discrete-time system; **T. Furumochi**, **S. Murakami**, and **Y. Nagabuchi**, Stabilities in Volterra difference equations on a Banach space; **S. Guo** and **L. Huang**, Periodic oscillation for a class of delay difference systems; **Z. Guo** and **J. Yu**, Applications of critical point theory to difference equations; **D. Levi**, Lie symmetries for lattice equations; **X. Li** and **Z. Wang**, Global attractivity for a logistic equation with piecewise constant arguments; **X. Lin**, Bounded oscillation for a class of second order neutral delay difference equations; **K. Liu** and **H. Zhang**, Asymptotic behavior in nonlinear discrete-time neural networks with delayed feedback; **Y. Liu**, **L. Huang**, and **Z. Yuan**, Asymptotic behavior and periodicity of solutions for a difference equation with piecewise constant nonlinearity; **Y. Liu**, **Z. Zhou**, and **W. Ge**, Positive solutions of a non-autonomous delay model of single population; **H. Matsunaga**, Stability regions for a class of delay difference systems; **M. Migda**, Oscillation and nonoscillation results for higher-order nonlinear difference equations; **C. Pötzsche**, Stability of center fiber bundles for nonautonomous difference equations; **R. J. Sacker** and **H. F. von Bremen**, Bifurcation of maps and cycling in genetic systems; **E. Schmeidel**, Nonoscillation and oscillation theorems for a fourth order nonlinear difference equation; **H. Sedaghat**, On the equation $x_{n+1} = cx_n + f(x_n - x_{n-1})$; **C. Tian**, **J. Zhang**, and **Z. Ji**, Stability criteria for a kind of delay functional equation; **L. Wang** and **X. Zou**, Exponential stability of delay difference equations with applications to neural networks; **X. Wang** and **L. Liao**, Asymptotic behavior of solutions of linear difference-differential equations with oscillating coefficients; **W. Wendi**, Analysis of a discrete predator-prey model; **H.-W. Wu** and **Y.-T. Xu**, Oscillation for nonautonomous neutral difference equations with variable coefficients; **Z. Yinggao**, Oscillation of higher-order nonlinear delay difference equations; **Z. Yuan**, **L. Huang**, and **Z. Zhou**, Coexistence of multiple attractive periodic solutions in a discrete-time neural network; **R. Y. Zhang**, **Z. C. Wang**, and **J. S. Yu**, Necessary and sufficient conditions for the existence of positive solutions of nonlinear difference equations; **Z. Zhou** and **Q. Zhang**, Periodic solutions of a class of difference systems; **H. Zhu** and **L. Huang**, Dynamic analysis of a discrete-time network of two neurons with delayed feedback; *Open problems and conjectures:* **S. Elaydi**, Open problems and conjectures; **H. Brunner**, Discretization of Volterra integral equations with weakly singular kernels; **S. Elaydi**, Nonautonomous difference equations: Open problems and conjectures; **E. A. Grove** and **G. Ladas**, On period-two solutions of $x_{n+1} = \frac{\alpha+\beta x_n+\gamma x_{n-1}}{A+Bx_n+Cx_{n-1}}$; **R. J. Sacker** and **H. F. von Bremen**, Open problems on cycling in genetic systems; **J. Wu**, On periodic solutions of systems of two difference equations.

Fields Institute Communications, Volume 42

July 2004, approximately 448 pages, Hardcover, ISBN 0-8218-3354-5, LC 2004040309, 2000 *Mathematics Subject Classification*: 00B20, 34K11, 34K13, 34K20, 34K28, 34K30, 39A05, 39A11, **All AMS members $95**, List $119, Order code FIC/42N



Inverse Problems and Spectral Theory

Hiroshi Isozaki, *Tokyo Metropolitan University*, Editor

This volume grew out of a workshop on spectral theory of differential operators and inverse problems held at the Research Institute for Mathematical Sciences (Kyoto University). The gathering of nearly 100 participants at the conference suggests the increasing interest in this field of research.

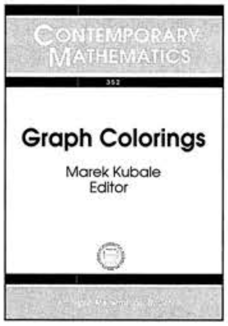
The focus of the book is on spectral theory for differential operators and related inverse problems. It includes selected topics from the following areas: electromagnetism, elasticity, the Schrödinger equation, differential geometry, and numerical analysis. The material is suitable for graduate students and researchers interested in inverse problems and their applications.

Contents: **V. G. Romanov** and **M. Yamamoto**, On the determination of wave speed and potential in a hyperbolic equation by two measurements; **Y. Kurylev**, **M. Lassas**, and **E. Somersalo**, Focusing waves in electromagnetic inverse problems; **H. Ammari** and **H. Kang**, Reconstruction of conductivity inhomogeneities of small diameter via boundary measurements; **S. Kim** and **M. Yamamoto**, Unique determination of inhomogeneity in a stationary isotropic Lamé system with variable coefficients; **M. Ikehata**, Mittag-Leffler's function and extracting from Cauchy data; **G. Eskin** and **J. Ralston**, On the inverse boundary value problem for linear isotropic elasticity and Cauchy-Riemann systems; **M. Ikehata** and **G. Nakamura**, Pointwise reconstruction of the jump at the boundaries of inclusions; **S.-i. Nakagiri** and **J. Ha**, Constant parameters identification problems of coupled sine-Gordon equations; **D. Chelkak**, **P. Kargaev**, and **E. Korotyaev**, Inverse problem for harmonic oscillator perturbed by potential; **A. Melin**, Some transforms in potential scattering in odd dimension; **G. Uhlmann** and **A. Vasy**, Inverse problems in N-body scattering; **A. Katsuda**, Asymptotics of heat kernels on nilpotent coverings and related topics; **R. Kuwabara**, Eigenvalues associated with a periodic orbit of the magnetic flow; **H. Isozaki**, Inverse problems and hyperbolic manifolds; **T. Takiguchi**, Reconstruction of measurable plane sets from their orthogonal projections; **K. Iijima**, **K. Shirota**, and **K. Onishi**, A numerical computation for inverse boundary value problems by using the adjoint method; **H. Urakawa**, The Dirichlet eigenvalue problem, the finite element method and graph theory; **J. Cheng**, **Y. C. Hon**, and **Y. B. Wang**, A numerical method for the discontinuous solutions of Abel integral equations.

Contemporary Mathematics, Volume 348

April 2004, 243 pages, Softcover, ISBN 0-8218-3421-5, LC 2004043758, 2000 *Mathematics Subject Classification*: 34A55, 34K29, 35R30, 44A12, 58J50, 65L15, 65N21, 81U40, **All AMS members $55**, List $69, Order code CONM/348N

Discrete Mathematics and Combinatorics



Graph Colorings

Marek Kubale, *Gdańsk University of Technology, Poland*, Editor

Graph coloring is one of the oldest and best-known problems of graph theory. As people grew accustomed to applying the tools of graph theory to the solutions of real-world technological and organizational problems, new chromatic models emerged as a natural way of tackling many practical situations. Statistics show that graph coloring is one of the central issues in the collection of several hundred classical combinatorial problems.

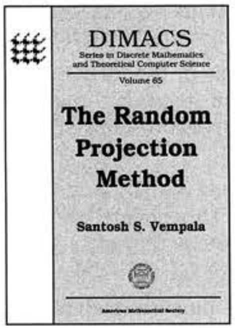
This book is devoted to problems in graph coloring, which can be viewed as one area of discrete optimization. Chapters are dedicated to various models and are largely independent of one another. In each chapter, the author highlights algorithmic aspects of the presented models, i.e., the construction of polynomial-time algorithms for graph coloring.

This is an expanded and updated translation of the prizewinning book originally published in Polish, *Optymalizacja dyskretna. Modele i metody kolorowania grafów*. It is suitable for graduate students and researchers interested in graph theory.

Contents: **A. Kosowski** and **K. Manuszewski**, Classical coloring of graphs; **P. Borowiecki**, On-line coloring of graphs; **H. Furmańczyk**, Equitable coloring of graphs; **M. Malafiejski**, Sum coloring of graphs; **R. Janczewski**, T-coloring of graphs; **D. Dereniowski**, Rank coloring of graphs; **M. Kubale**, Harmonious coloring of graphs; **K. Giaro**, Interval edge-coloring of graphs; **A. Nadolski**, Circular coloring of graphs; **J. Białogrodzki**, Path coloring and routing in graphs; **K. Piwakowski**, List colorings of graphs; **T. Dzido**, Ramsey colorings of complete graphs; **P. Żyliński**, Placing guards in art galleries by graph coloring; Bibliography; Index; Authors' addresses.

Contemporary Mathematics, Volume 352

July 2004, 208 pages, Softcover, ISBN 0-8218-3458-4, LC 2004046151, 2000 *Mathematics Subject Classification*: 05C15, **All AMS members $47**, List $59, Order code CONM/352N



DIMACS
Series in Discrete Mathematics and Theoretical Computer Science
Volume 65
The Random Projection Method
Santosh S. Vempala

The Random Projection Method

For Classroom Use

Santosh S. Vempala,

Massachusetts Institute of Technology, Cambridge

A very nice piece of work — the author succeeds in tying together a lot of recent developments in algorithms under an appealing theme.
—Professor Jon Kleinberg, Cornell University

This is an elegant monograph, dense in ideas and techniques, diverse in its applications, and above all, vibrant with the author's enthusiasm for the area.
—from the Foreword by Christos H. Papadimitriou, University of California, Berkeley

Random projection is a simple geometric technique for reducing the dimensionality of a set of points in Euclidean space while preserving pairwise distances approximately. The technique plays a key role in several breakthrough developments in the field of algorithms. In other cases, it provides elegant alternative proofs.

The book begins with an elementary description of the technique and its basic properties. Then it develops the method in the context of applications, which are divided into three groups. The first group consists of combinatorial optimization problems such as maxcut, graph coloring, minimum multicut, graph bandwidth and VLSI layout. Presented in this context is the theory of Euclidean embeddings of graphs. The next group is machine learning problems, specifically, learning intersections of halfspaces and learning large margin hypotheses. The projection method is further refined for the latter application. The last set consists of problems inspired by information retrieval, namely, nearest neighbor search, geometric clustering and efficient low-rank approximation. Motivated by the first two applications, an extension of random projection to the hypercube is developed here. Throughout the book, random projection is used as a way to understand, simplify and connect progress on these important and seemingly unrelated problems.

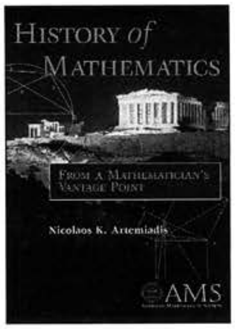
The book is suitable for graduate students and research mathematicians interested in computational geometry.

Contents: Random projection; *Combinatorial optimization:* Rounding via random projection; Embedding metrics in Euclidean space; Euclidean embeddings: Beyond distance preservation; *Learning theory:* Robust concepts; Intersections of half-spaces; *Information retrieval:* Nearest neighbors; Indexing and clustering; Bibliography; Appendix.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 65

August 2004, 103 pages, Hardcover, ISBN 0-8218-2018-4, LC 2004046181, 2000 *Mathematics Subject Classification*: 68Q25, 68W20, 90C27, 68Q32, 68P20, **All AMS members $31**, List $39, Order code DIMACS/65N

General and Interdisciplinary



History of Mathematics

From a Mathematician's Vantage Point

Nicolaos K. Artemiadis,

Academy of Athens

From a review of the Greek edition:

The book's originality lies in its structure, which brings to the surface significant links between the mathematics of centuries ago and up to date abstract mathematical theories ... The author has written an elegant and charming book not lacking in substance and depth. We welcome this work as an aid in the wider realms of mathematical education.
—Zentralblatt MATH

This book offers a very interesting panorama of the development of mathematics from the ancient Babylonians and Greeks to the present. It is written in a lucid style with very readable mathematical content. Understanding the material requires some broad mathematical education, but not a lot of specialized knowledge.

One of the strongest sections deals with the accomplishments of the Greeks. The author clearly explains the problems tackled in ancient Greece, places them in context, outlines the accomplishments (some with concise proofs), and compares these with our present understanding of the subject. He also places the mathematical achievements of ancient Greece in the context of early Ionian Philosophy, Platonism, Aristotelism, or in the mindset of the Alexandrians.

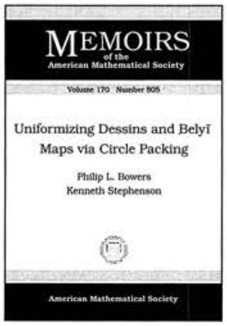
The chapters on the seventeenth and eighteenth centuries are presented clearly with emphasis on the great figures of these two centuries. Mathematics of the nineteenth and twentieth centuries are presented more thematically than chronologically. Analysis, in particular functional analysis, receives a very good overview. An appendix contains a transcript of the talk by Laurent Schwartz on the historical roots and basic notions of the theory of distributions.

Other chapters discuss topics such as modern algebra, set theory, logic, group representations, calculus of variations, celestial mechanics, fractals, the fast Fourier transform, and wavelets. The book is supplemented with a chronological table and two detailed indices. It is suitable for graduate students, research mathematicians, and those interested in the history of mathematics and related areas.

Contents: *Part I:* Introduction; Remarks on the history and the philosophy of mathematics; Mathematics of the Egyptians; Mathematics of the Babylonians; Prime numbers; Mathematics of the Greeks–The beginnings; Pythagoras–The Pythagorean school; Heraclitus, Parmenides, Zeno, Empedocles, and Democritus; The mathematical school of Athens; Plato and Aristotle; Groups; The impossibility of solving the three classical problems of antiquity; Euclid; Hilbert's foundation of Euclidean geometry; Basic properties of axiomatic systems; Spaces and geometries; Non-Euclidean geometries; The geometry of experience; Aristarchus, Archimedes, Apollonius, and Eratosthenes; The period from 200 B.C. to 500 A.D. in Alexandria; A brief review of the history of Greek mathematics; Mathematics of China and India; Mathematics of the Arabs; Europe during the middle ages; Renaissance (1400-1600); The seventeenth century; The eighteenth century; *Part II:* Short biographies of mathematicians of the 19th and 20th centuries; Revival of synthetic geometry; The system of real numbers; The system of complex numbers and the quaternions; The fundamental theorem of algebra; Set theory; Logic; Functional analysis; Topology; Functions of real variables; Abstract algebra; Categories and functors; Recent discoveries and achievements; Language; The fast Fourier transform; The theory of wavelets; A short curriculum vitae of the author; Bibliography; Chronological table; Subject index; Name index.

September 2004, approximately 454 pages, Hardcover, ISBN 0-8218-3403-7, LC 2004046178, 2000 *Mathematics Subject Classification*: 01-01, 01A05, **All AMS members $47**, List $59, Order code HISMATN

Geometry and Topology


MEMOIRS
of the
American Mathematical Society
Volume 170 Number 805
Uniformizing Dessins and Belyĭ
Maps via Circle Packing
Philip L. Bowers
Kenneth Stephenson
American Mathematical Society

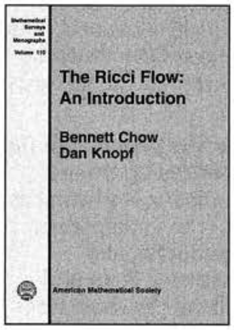
Uniformizing Dessins and Belyĭ Maps via Circle Packing

Philip L. Bowers, *Florida State University, Tallahassee*, and **Kenneth Stephenson**, *University of Tennessee, Knoxville*

Contents: Introduction; Dessins d'enfants; Discrete Dessins *via* circle packing; Uniformizing Dessins; A menagerie of Dessins d'enfants; Computational issues; Additional constructions; Non-equilateral triangulations; The discrete option; Appendix: Implementation; Bibliography.

Memoirs of the American Mathematical Society, Volume 170, Number 805

July 2004, 97 pages, Softcover, ISBN 0-8218-3523-8, LC 2004046104, 2000 *Mathematics Subject Classification*: 52C26, 30F10; 30C62, **Individual member $33**, List $55, Institutional member $44, Order code MEMO/170/805N


Mathematical Surveys and Monographs
Volume 110
The Ricci Flow:
An Introduction
Bennett Chow
Dan Knopf
American Mathematical Society

The Ricci Flow: An Introduction

Bennett Chow, *University of California, San Diego*, and **Dan Knopf**, *University of Texas, Austin*

The Ricci flow is a powerful technique that integrates geometry, topology, and analysis. Intuitively, the idea is to set up a PDE that evolves a metric according to its Ricci curvature. The resulting equation has much in common with the heat equation, which tends to "flow" a given function to ever nicer functions. By analogy, the Ricci flow evolves an initial metric into improved metrics.

Richard Hamilton began the systematic use of the Ricci flow in the early 1980s and applied it in particular to study 3-manifolds. Grisha Perelman has made recent breakthroughs aimed at completing Hamilton's program.

The Ricci flow method is now central to our understanding of the geometry and topology of manifolds. This book is an introduction to that program and to its connection to Thurston's geometrization conjecture.

The authors also provide a "Guide for the hurried reader", to help readers wishing to develop, as efficiently as possible, a nontechnical appreciation of the Ricci flow program for 3-manifolds, i.e., the so-called "fast track".

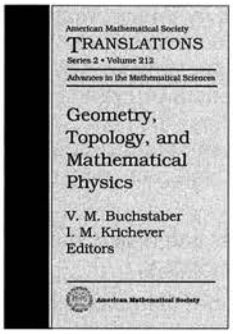
The book is suitable for geometers and others who are interested in the use of geometric analysis to study the structure of manifolds.

Contents: The Ricci flow of special geometries; Special and limit solutions; Short time existence; Maximum principles; The Ricci flow on surfaces; Three-manifolds of positive Ricci curvature; Derivative estimates; Singularities and the limits of their dilations; Type I singularities; The Ricci calculus; Some results in comparison geometry; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 110

July 2004, 325 pages, Hardcover, ISBN 0-8218-3515-7, LC 2004046148, 2000 *Mathematics Subject Classification*: 53C44, 53C21, 58J35, 53C25, 35K55, 57M50, 35K57, **All AMS members $67**, List $84, Order code SURV/110N

Mathematical Physics


American Mathematical Society
TRANSLATIONS
Series 2 • Volume 212
Advances in the Mathematical Sciences
Geometry,
Topology, and
Mathematical
Physics
V. M. Buchstaber
I. M. Krichever
Editors
American Mathematical Society

Geometry, Topology, and Mathematical Physics

V. M. Buchstaber, *Steklov Mathematical Institute, Russian Academy of Sciences, Moscow*, and **I. M. Krichever**, *Columbia University, NY, and Institute for Theoretical and Experimental Physics, Moscow*, Editors

This volume contains a selection of papers based on presentations given at the S. P. Novikov seminar held at the Steklov Mathematical Institute in Moscow. Topics and speakers were chosen by the well-known expert, S. P. Novikov, one of the leading mathematicians of the twentieth century. His diverse interests are the tradition of the seminar and are reflected in the topics presented in the book.

The book begins with Novikov's paper analyzing the position of mathematics and theoretical physics at the beginning of the new millennium. Following is an interview with Novikov published in the *Newsletter of the European Mathematical Society* presenting the genesis of many of his ideas and his scientific school. The remaining articles address topics in geometry, topology, and mathematical physics. The volume is suitable for graduate students and researchers interested in the corresponding areas of mathematics and physics.

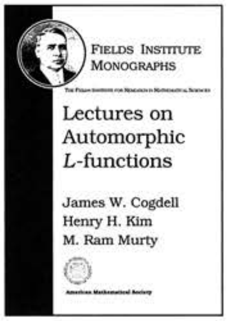
This item will also be of interest to those working in geometry and topology.

Contents: S. P. Novikov, The second half of the 20th century and its conclusion: Crisis in the physics and mathematics community in Russia and in the West; **V. M. Buchstaber**, Interview with Sergey P. Novikov; **V. M. Buchstaber** and **S. Yu. Shorina**, The w-function of the KdV hierarchy; **A. Campillo**, **F. Delgado**, and **S. M. Gusein-Zade**, On the zeta functions of a meromorphic germ in two variables; **B. Dubrovin**, On almost duality for Frobenius manifolds; **I. A. Dynnikov**, Finitely presented semigroups in knot theory. Oriented case; **M. Farber** and **S. Yuzvinsky**, Topological robotics: Subspace arrangements and collision free motion planning; **P. G. Grinevich** and **P. M. Santini**, The initial-boundary value problem on the interval for the nonlinear Schrödinger equation. The algebro-geometric approach. I; **H. M. Khudaverdian** and **T. Voronov**, On odd Laplace operators. II; **Yu. Klimov**, **A. Korzh**, and **S. Natanzon**, From 2D Toda hierarchy to conformal maps for domains of the Riemann sphere; **I. Krichever**, Integrable chains on algebraic curves; **S. B. Kuksin**, Fifteen years of KAM for PDE; **D. V. Millionschikov**, Graded filiform Lie algebras and symplectic nilmanifolds; **A. G. Sergeev**, Adiabatic limit in the Seiberg–Witten equations; **O. K. Sheinman**, Affine Krichever–Novikov algebras, their representations and applications; **I. A. Taimanov**, Tame integrals of motion and o-minimal structures.

American Mathematical Society Translations—Series 2 (*Advances in the Mathematical Sciences*), Volume 212

May 2004, 324 pages, Hardcover, ISBN 0-8218-3613-7, LC 91-640741, 2000 *Mathematics Subject Classification*: 00B15; 58-06, **All AMS members $95**, List $119, Order code TRANS2/212N

Number Theory


Fields Institute Monographs

Lectures on Automorphic L-functions

James W. Cogdell
Henry H. Kim
M. Ram Murty

American Mathematical Society

Lectures on Automorphic L-functions

For Classroom Use

James W. Cogdell, *Oklahoma State University, Stillwater,* **Henry H. Kim**, *University of Toronto, ON, Canada,* and **M. Ram Murty**, *Queen's University, Kingston, ON, Canada*

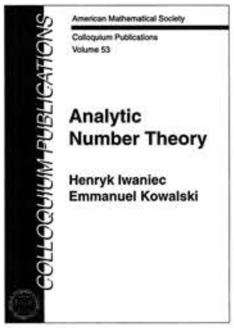
This book provides a comprehensive account of the crucial role automorphic L-functions play in number theory and in the Langlands program, especially the Langlands functoriality conjecture. There has been a recent major development in the Langlands functoriality conjecture by the use of automorphic L-functions, namely, by combining converse theorems of Cogdell and Piatetski-Shapiro with the Langlands-Shahidi method. This book provides a step-by-step introduction to these developments and explains how the Langlands functoriality conjecture implies solutions to several outstanding conjectures in number theory, such as the Ramanujan conjecture, Sato-Tate conjecture, and Artin's conjecture. It would be ideal for an introductory course in the Langlands program.

This item will also be of interest to those working in algebra and algebraic geometry.

Contents: *James W. Cogdell, Lectures on L-functions, converse theorems, and functoriality for GL_n:* Preface; Modular forms and their L-functions; Automorphic forms; Automorphic representations; Fourier expansions and multiplicity one theorems; Eulerian integral representations; Local L-functions: The non-Archimedean case; The unramified calculation; Local L-functions: The Archimedean case; Global L-functions; Converse theorems; Functoriality; Functoriality for the classical groups; Functoriality for the classical groups, II; *Henry H. Kim, Automorphic L-functions:* Introduction; Chevalley groups and their properties; Cuspidal representations; L-groups and automorphic L-functions; Induced representations; Eisenstein series and constant terms; L-functions in the constant terms; Meromorphic continuation of L-functions; Generic representations and their Whittaker models; Local coefficients and non-constant terms; Local Langlands correspondence; Local L-functions and functional equations; Normalization of intertwining operators; Holomorphy and bounded in vertical strips; Langlands functoriality conjecture; Converse theorem of Cogdell and Piatetski-Shapiro; Functoriality of the symmetric cube; Functoriality of the symmetric fourth; Bibliography; *M. Ram Murty, Applications of symmetric power L-functions:* Preface; The Sato-Tate conjecture; Maass wave forms; The Rankin-Selberg method; Oscillations of Fourier coefficients of cusp forms; Poincaré series; Kloosterman sums and Selberg's conjecture; Refined estimates for Fourier coefficients of cusp forms; Twisting and averaging of L-series; The Kim-Sarnak theorem; Introduction to Artin L-functions; Zeros and poles of Artin L-functions; The Langlands-Tunnell theorem; Bibliography.

Fields Institute Monographs, Volume 20

April 2004, 283 pages, Hardcover, ISBN 0-8218-3516-5, LC 2004046166, 2000 *Mathematics Subject Classification*: 11F70, 22E55, **All AMS members $63**, List $79, Order code FIM/20N


COLLOQUIUM PUBLICATIONS

American Mathematical Society
Colloquium Publications
Volume 53

Analytic Number Theory

Henryk Iwaniec
Emmanuel Kowalski

Analytic Number Theory

For Classroom Use

Henryk Iwaniec, *Rutgers University, Piscataway, NJ,* and **Emmanuel Kowalski**, *Université Bordeaux I, Talence, France*

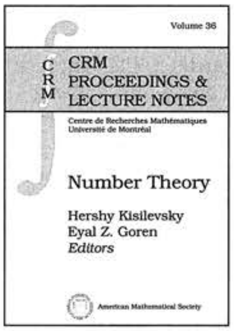
Analytic Number Theory distinguishes itself by the variety of tools it uses to establish results. One of the primary attractions of this theory is its vast diversity of concepts and methods. The main goals of this book are to show the scope of the theory, both in classical and modern directions, and to exhibit its wealth and prospects, beautiful theorems, and powerful techniques.

The book is written with graduate students in mind, and the authors nicely balance clarity, completeness, and generality. The exercises in each section serve dual purposes, some intended to improve readers' understanding of the subject and others providing additional information. Formal prerequisites for the major part of the book do not go beyond calculus, complex analysis, integration, and Fourier series and integrals. In later chapters automorphic forms become important, with much of the necessary information about them included in two survey chapters.

Contents: Introduction; Arithmetic functions; Elementary theory of prime numbers; Characters; Summation formulas; Classical analytic theory of L-functions; Elementary sieve methods; Bilinear forms and the large sieve; Exponential sums; The Dirichlet polynomials; Zero-density estimates; Sums over finite fields; Character sums; Sums over primes; Holomorphic modular forms; Spectral theory of automorphic forms; Sums of Kloosterman sums; Primes in arithmetic progressions; The least prime in an arithmetic progression; The Goldbach problem; The circle method; Equidistribution; Imaginary quadratic fields; Effective bounds for the class number; The critical zeros of the Riemann zeta function; The spacing of zeros of the Riemann zeta-function; Central values of L-functions; Bibliography; Index.

Colloquium Publications, Volume 53

July 2004, 615 pages, Hardcover, ISBN 0-8218-3633-1, LC 2004045081, 2000 *Mathematics Subject Classification*: 11Fxx, 11Lxx, 11Mxx, 11Nxx, 11T23, 11T24, 11R42, **All AMS members $79**, List $99, Order code COLL/53N


Volume 36
CRM PROCEEDINGS & LECTURE NOTES
Centre de Recherches Mathématiques Université de Montréal
Number Theory
Hershy Kisilevsky
Eyal Z. Goren
Editors
American Mathematical Society

Number Theory

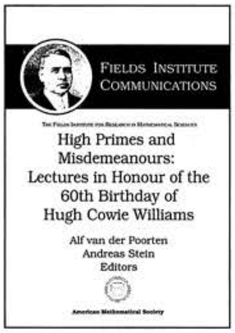
Hershy Kisilevsky, *Concordia University, Montreal, QC, Canada*, and **Eyal Z. Goren**, *McGill University, Montreal, QC, Canada*, Editors

This volume contains a collection of articles from the meeting of the Canadian Number Theory Association held at the Centre de Recherches Mathématiques (CRM) at the University of Montreal. The book represents a cross section of current research and new results in number theory. Topics covered include algebraic number theory, analytic number theory, arithmetic algebraic geometry, computational number theory, and Diophantine analysis and approximation. The volume contains both research and expository papers suitable for graduate students and researchers interested in number theory.

Contents: **M. J. Bertin**, Mesure de Mahler et régulateur elliptique: Preuve de deux relations *exotiques*; **A. Besser**, The p-adic height pairings of Coleman-Gross and of Nekovář; **J. M. Borwein** and **K.-K. S. Choi**, Dirichlet series for squares of sums of squares: A summary; **D. Burns**, Equivariant Whitehead torsion and refined Euler characteristics; **A. C. Cojocaru**, Questions about the reductions modulo primes of an elliptic curve; **C. Consani** and **M. Marcolli**, New perspectives in Arakelov geometry; **H. Darmon**, A fourteenth lecture on Fermat's last theorem; **W. Duke**, Number fields with large class group; **S. J. Gurak**, Period polynomials for $\mathbb{F}_q$ of fixed small degree; **J. Hanke**, Some recent results about (ternary) quadratic forms; **L. Jones**, An extension of a theorem of D. H. Lehmer; **S.-i. Katayama**, **C. Levesque**, and **T. Nakahara**, On a family of real bicyclic biquadratic fields; **C. Khare**, Belyi parametrisations of elliptic curves and congruence defects; **H. H. Kim**, An application of exterior square functoriality of GL_4; Asai lift; **M. Laurent**, Totally real integral points on a plane algebraic curve; **L. Murata** and **C. Pomerance**, On the largest prime factor of a Mersenne number; **M. R. Murty** and **S. Sumner**, On the p-adic series $\sum_{n=1}^{\infty} n^k \cdot n!$; **K. Ono**, Hecke operators and the q-expansion of modular forms; **D. P. Roberts**, An *ABC* construction of number fields; **D. Roy**, Diophantine approximation in small degree; **L. Smithline**, Compact operators with rational generation; **V. Talamanca**, The canonical height of a finite étale K-algebra.

CRM Proceedings & Lecture Notes, Volume 36

July 2004, approximately 330 pages, Softcover, ISBN 0-8218-3331-6, LC 2004046301, 2000 *Mathematics Subject Classification*: 11-XX, **All AMS members $79**, List $99, Order code CRMP/36N


FIELDS INSTITUTE COMMUNICATIONS
High Primes and Misdemeanours: Lectures in Honour of the 60th Birthday of Hugh Cowie Williams
Alf van der Poorten
Andreas Stein
Editors
American Mathematical Society

High Primes and Misdemeanours: Lectures in Honour of the 60th Birthday of Hugh Cowie Williams

Alf van der Poorten, *Centre for Number Theory Research, Killara, NSW, Australia*, and **Andreas Stein**, *University of Illinois at Urbana-Champaign*, Editors

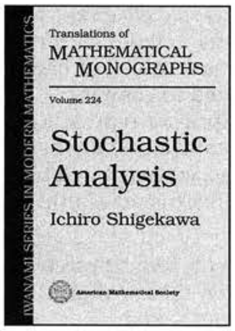
This volume consists of a selection of papers based on presentations made at the international conference on number theory held in honor of Hugh Williams' sixtieth birthday. The papers address topics in the areas of computational and explicit number theory and its applications. The material is suitable for graduate students and researchers interested in number theory.

Contents: **A. Agashe**, **K. Lauter**, and **R. Venkatesan**, Constructing elliptic curves with a known number of points over a prime field; **S. Akiyama**, **T. Borbély**, **H. Brunotte**, **A. Pethő**, and **J. M. Thuswaldner**, On a generalization of the radix representation–A survey; **W. D. Banks**, **J. B. Friedlander**, **C. Pomerance**, and **I. E. Shparlinski**, Multiplicative structure of values of the Euler function; **W. D. Banks** and **I. E. Shparlinski**, Congruences and exponential sums with the Euler function; **L. D. Baumert** and **D. M. Gordon**, On the existence of cyclic difference sets with small parameters; **D. J. Bernstein**, Doubly focused enumeration of locally square polynomial values; **W. Bosma**, Cubic reciprocity and explicit primality tests for $h \cdot 3^k \pm 1$; **R. P. Brent** and **P. Zimmermann**, Algorithms for finding almost irreducible and almost primitive trinomials; **J. Brillhart**, Commentary on Lucas' test; **J. Buchmann**, **T. Takagi**, and **U. Vollmer**, Number field cryptography; **D. A. Buell**, **S. Devarkal**, and **H. A. Wake**, Reconfigurable computing machines and their applications in computational number theory; **J. Buhler**, **C. Pomerance**, and **L. Robertson**, Heuristics for class numbers of prime-power real cyclotomic fields; **H. Cohen**, Counting A_4 and S_4 number fields with given resolvent cubic; **K. Dilcher** and **J. Knauer**, On a conjecture of Feit and Thompson; **M. García**, **J. M. Pedersen**, and **H. te Riele**, Amicable pairs, a survey; **A. Granville**, On the research contributions of Hugh C. Williams; **H. G. Grundman** and **L. E. Lippincott**, Hilbert modular fourfolds of arithmetic genus one; **E. Herrmann** and **P. G. Walsh**, Values of ternary recurrence sequences and torsion on certain curves arising from the work of Hugh Williams; **S. Hernández** and **F. Luca**, Divisibility of exponents of class groups of pure cubic number fields; **J. Holden** and **P. Moree**, New conjectures and results for small cycles of the discrete logarithm; **M. Jacobson, Jr.**, **A. Menezes**, and **A. Stein**, Hyperelliptic curves and cryptography; **S. Louboutin**, Remarks on S. Chowla's hypothesis implying that $L(s,\chi) > 0$ for $s > 0$ and for real characters χ; **S. Müller**, On the computation of cube roots modulo p; **R. D. Patterson** and **A. J. van der Poorten**, Jeepers, creepers, ...; **K. Rubin** and **A. Silverberg**, Algebraic tori in cryptography; **J. P. Sorenson**, An analysis of the generalized binary GCD algorithm; **E. Teske**, An elliptic curve trapdoor system (extended abstract); **A. J. van der Poorten**, Periodic continued fractions and elliptic curves; **S. S. Wagstaff, Jr.**, The Cunningham project; **A. Weng**, Extensions and improvements for the CM method for genus two; **A. J. van der Poorten** and **A. Stein**, Advice to referees of submissions to *High Primes and Misdemeanours*.

Fields Institute Communications, Volume 41

June 2004, 392 pages, Hardcover, ISBN 0-8218-3353-7, LC 2004047642, 2000 *Mathematics Subject Classification*: 11Rxx, 11Yxx, 94Axx, 11Axx, 11Gxx, 14Gxx, 11-04; 11Txx, 14Hxx, 11Bxx, **All AMS members $88**, List $110, Order code FIC/41N

Probability


Translations of MATHEMATICAL MONOGRAPHS
Volume 224
Stochastic Analysis
Ichiro Shigekawa
American Mathematical Society
IWANAMI SERIES IN MODERN MATHEMATICS

Stochastic Analysis

For Classroom Use

Ichiro Shigekawa, *Kyoto University, Japan*

Stochastic analysis is often understood as the analysis of functionals defined on the Wiener space, i.e., the space on which the Wiener process is realized. Since the Wiener space is infinite-dimensional, it requires a special calculus, the so-called Malliavin calculus.

This book provides readers with a concise introduction to stochastic analysis, in particular, to the Malliavin calculus. It contains a detailed description of all the technical tools necessary to describe the theory, such as the Wiener process, the Ornstein-Uhlenbeck process, and Sobolev spaces. It also presents applications of stochastic calculus to the study of stochastic differential equations. The volume is suitable for graduate students and research mathematicians interested in probability and random processes.

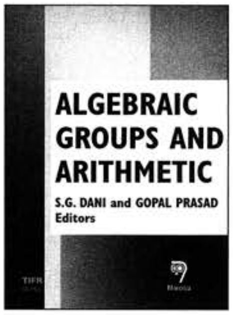
Contents: Wiener space; Orenstein-Uhlenbeck process; The Littlewood-Paley-Stein inequality; Sobolev spaces on an abstrct Wiener space; Absolute continuity of distributions and smoothness of density functions; Application to stochastic differential equations; Perspectives on current research; Bibliography; Index.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*), Volume 224

June 2004, 182 pages, Softcover, ISBN 0-8218-2626-3, LC 2004047722, 2000 *Mathematics Subject Classification*: 60H07; 60H30, **All AMS members $31**, List $39, Order code MMONO/224N

More Publications Available from the AMS

Algebra and Algebraic Geometry


ALGEBRAIC GROUPS AND ARITHMETIC
S.G. DANI and GOPAL PRASAD
Editors
TIFR
Narosa

Algebraic Groups and Arithmetic

S. G. Dani, *Tata Institute of Fundamental Research, Mumbai, India*, and Gopal Prasad, *University of Michigan, Ann Arbor*, Editors

Major advances have been made in recent decades in algebraic groups and arithmetic. The School of Mathematics of the Tata Institute of Fundamental Research, under the leadership of Professor M. S. Raghunathan, has been a significant contributor to this progress. This collection of papers grew out of a conference held in honor of Professor Raghunathan's sixtieth birthday.

The volume contains original papers contributed by leading experts. Topics covered include group-theoretic aspects, Diophantine approximation, modular forms, representation theory, interactions with topology and geometry, and dynamics on homogeneous spaces. Particularly noteworthy are two expository articles on Professor Raghunathan's work by the late Armand Borel and Gopal Prasad.

The book is suitable for graduate students and researchers interested in algebra and algebraic geometry.

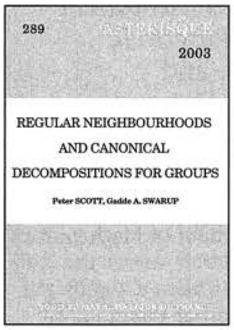
A publication of the Narosa Publishing House for Tata Institute of Fundamental Research. Distributed worldwide except in India, Bangladesh, Bhutan, Maldavis, Nepal, Pakistan, and Sri Lanka.

Contents: **A. Borel**, On the work of M. S. Raghunathan; **S. G. Dani**, On stabilizers of continuous actions of Lie groups; **C. S. Aravinda** and **F. T. Farrel**, Exotic structures and quaternionic hyperbolic manifolds; **Y. Benoist**, Convexes divisibles; **H. Garland**, Convergence and the constant term; **W. M. Goldman**, The complex-symplectic geometry of $SL(2,C)$-characters over surfaces; **D. Kazhdan** and **A. Polischuk**, Vectors and automorphic functionals; **D. Kleinbock**, Baker-Sprindzuk conjectures for complex analytic manifolds; **B. Klingler**, Transformation de type Poisson relative aux groupes d'Iwahori; **W. Kuo** and **M. R. Murty**, Summatory functions of elements in Selberg's class; **H. Oh**, On a problem concerning arithmeticity of discrete groups acting on $H \times \cdots \times H$; **M. Larsen** and **A. Lubotzky**, Normal subgroup growth of linear groups: the G_2, F_4, E_8-theorem; **J. Millson**, The cohomology with local coefficients of compact hyperbolic manifolds; **G. Margulis**, Random walks on the space of lattices and the finiteness of covolumes of arithmetic subgroups; **D. Morris**, Real representations of semisimple Lie algebras have $\mathbb{Q}$-forms; **G. Prasad**, On some of Raghunathan's work; **C. S. Rajan**, Reduction to the semistable case; **D. Ramakrishnan**, Fourfolds and poles of L-functions; **J. Rohlfs** and

B. Speh, Pseudo-Eisenstein forms and cohomology of arithmetic groups II; **S. Kumar** and **J. F. Thomsen**, A new realization of the cohomology of Springer fibers; **T. A. Springer**, Combinatorics of B-orbits in a wonderful compactification; **V. I. Yanchevskiui**, Whitehead groups and groups of R-equivalence classes of linear algebraic groups of non-commutative classical type over some virtual fields; **T. N. Venkataramana**, Restriction maps and the first Betti number.

Tata Institute of Fundamental Research

April 2004, 600 pages, Hardcover, ISBN 81-7319-618-4, 2000 *Mathematics Subject Classification*: 22Exx, 20Gxx, 11Fxx, **All AMS members $40**, List $50, Order code TIFR/6N



289 ASTÉRISQUE 2003

REGULAR NEIGHBOURHOODS AND CANONICAL DECOMPOSITIONS FOR GROUPS

Peter SCOTT, Gadde A. SWARUP

Regular Neighbourhoods and Canonical Decompositions for Groups

Peter Scott, *University of Michigan, Ann Arbor*, and **Gadde A. Swarup**, *University of Melbourne, Victoria, Australia*

In this book, the authors find canonical decompositions for (almost) finitely presented groups which essentially specialize to the classical JSJ-decomposition when restricted to the fundamental groups of Haken manifolds. Obtained are the decompositions that are invariant under automorphisms of the group. A crucial new ingredient is the concept of a regular neighbourhood of a family of almost invariant subsets of a group. An almost invariant set is an analogue of an immersion.

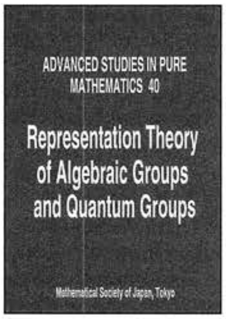
The material is suitable for graduate students and research mathematicians interested in algebra and algebraic geometry.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; The characteristic submanifold; Preliminaries; Algebraic regular neighbourhoods: Construction; Enclosing; Algebraic regular neighbourhoods: Enclosing; Algebraic regular neighbourhoods: Existence and uniqueness; Coends when the commensuriser is small; Coends when the commensuriser is large; Canonical decompositions over two-ended groups when commensurisers are small; Canonical decompositions over two-ended groups when commensurisers are large; Examples; Canonical decompositions over VPC groups of a given length; Canonical decompositions over VPC groups of two successive lengths; Canonical decompositions over virtually abelian groups; Previous decompositions over two-ended subgroups; Extensions; Appendix; Bibliography; Index.

Astérisque, Number 289

December 2003, 234 pages, Softcover, ISBN 2-85629-146-5, 2000 *Mathematics Subject Classification*: 20E06, 20E08, 20E34, 20F65, 57M07, 57M50, 57N12, 57N16, **Individual member $52**, List $58, Order code AST/289N



ADVANCED STUDIES IN PURE MATHEMATICS 40

Representation Theory of Algebraic Groups and Quantum Groups

Mathematical Society of Japan, Tokyo

Representation Theory of Algebraic Groups and Quantum Groups

Toshiaki Shoji, *Nagoya University, Japan*, **Masaki Kashiwara**, *RIMS, Kyoto University, Japan*, **Noriaki Kawanaka**, *Osaka University, Japan*, **George Lusztig**, *Massachusetts Institute of Technology, Cambridge*, and **Ken-ichi Shinoda**, *Sophia University, Tokyo, Japan*, Editors

This book is a collection of research and survey papers written by speakers at the Mathematical Society of Japan's 10th International Conference. It presents a comprehensive overview of developments in representation theory of algebraic groups and quantum groups. Particularly noteworthy are papers containing remarkable results concerning Lusztig's conjecture on cells in affine Weyl groups.

The following topics were discussed: cells in affine Weyl groups, tilting modules, tensor categories attached to cells in affine Weyl groups, representations of algebraic groups in positive characteristic, representations of Hecke algebras, Ariki-Koike and cyclotomic q-Schur algebras, cellular algebras and diagram algebras, Gelfand-Graev representations of finite reductive groups, Green functions associated to complex reflection groups, induction theorem for Springer representations, representations of Lie algebras in positive characteristic, representations of quantum affine algebras, extremal weight modules, crystal bases, tropical Robinson-Schensted-Knuth correspondence, and more.

The material is suitable for graduate students and research mathematicians interested in representation theory of algebraic groups, Hecke algebras, quantum groups, and combinatorial theory.

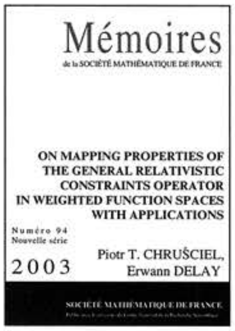
Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Contents: H. H. Anderson, Cells in affine Weyl groups and tilting modules; **S. Ariki** and **A. Mathas**, Heche algebras with a finite number of indecomposable modules; **S. Arkhipov**, Algebraic construction of contragradient quasi-Verma modules in positive characteristic; **R. Bezrukavnikov**, On tensor categories attached to cells in affine Weyl groups; **D. Gaitsgory**, Appendix: Braiding compatibilities; **R. Bezrukavnikov** and **V. Ostrik**, On tensor categories attached to cells in affine Weyl groups II; **C. W. Curtis** and **K.-i. Shinoda**, Zeta functions and functional equations associated with the components of the Gelfand-Graev representations of a finite reductive group; **J. J. Graham** and **G. I. Lehrer**, Cellular algebras and diagram algebras in representation theory; **J. C. Jantzen**, Representations of Lie algebras in positive characteristic; **S.-J. Kang**, Quantum affine algebras and crystal bases; **G. Lusztig**, An induction theorem for Springer's representations; **A. Mathas**, The representation theory of the Ariki-Koike and cyclotomic q-Schur algebras; **S. Naito** and **D. Sagaki**, Crystal bases and diagram automorphisms; **H. Nakajima**, Extremal weight modules of quantum affine algebras; **M. Noumi** and **Y. Yamada**, Tropical Robinson-Schensted-Knuth correspondence and birational Weyl group actions; **T. Shoji**, Green functions attached to limit symbols; **T. A. Springer**, Cells for a Hecke algebra representation; **N. Xi**, On the characterization of the set $\mathcal{D}_1$ of the affine Weyl group of type $\tilde{A}_n$.

Advanced Studies in Pure Mathematics, Volume 40

February 2004, 512 pages, Hardcover, ISBN 4-931469-25-6, 2000 *Mathematics Subject Classification*: 17Bxx, 20Cxx, 20Gxx; 14Fxx, 14Lxx, 16Wxx, 22Exx, **All AMS members $93**, List $116, Order code ASPM/40N

Analysis


Mémoires
de la SOCIÉTÉ MATHÉMATIQUE DE FRANCE
ON MAPPING PROPERTIES OF THE GENERAL RELATIVISTIC CONSTRAINTS OPERATOR IN WEIGHTED FUNCTION SPACES WITH APPLICATIONS
Numéro 94
Nouvelle série
2003
Piotr T. CHRUŚCIEL, Erwann DELAY
SOCIÉTÉ MATHÉMATIQUE DE FRANCE

On Mapping Properties of the General Relativistic Constraints Operator in Weighted Function Spaces, with Applications

Piotr T. Chruściel and **Erwann Delay**, *Université de Tours, France*

In this book, the authors prove perturbation and gluing results for solutions of the general relativistic constraints with controlled boundary behavior or asymptotic behavior. This is obtained by a study of the linearized equation in weighted spaces *à la* Corvino-Schoen. Among other methods, this can be used to prove existence of non-trivial asymptotically simple vacuum space-times.

The book is suitable for graduate students and research mathematicians interested in analysis.

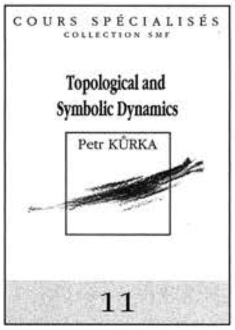
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; The constraints map; Isomorphism theorems; An asymptotic inequality; Compact boundaries; Conformally compactifiable initial data; Asymptotically flat initial data; Applications; Weighted Sobolev and weighted Hölder spaces; Sufficient conditions for the scaling property; Weighted Poincaré inequalities; Weighted estimates for vector fields; Poincaré charges; The reference family of Kerr metrics; Uniform local invertibility; Small initial data on a bounded domain in $\mathbb{R}^3$; Bibliography.

Mémoires de la Société Mathématique de France, Number 94

December 2003, 103 pages, Softcover, ISBN 2-85629-145-7, 2000 *Mathematics Subject Classification*: 83C05, **Individual member $32**, List $36, Order code SMFMEM/94N

Differential Equations



Topological and Symbolic Dynamics

Petr Kůrka, *Charles University, Prague, Czech Republic*

A dynamical system is a continuous self-map of a compact metric space. Topological dynamics studies the iterations of such a map, or equivalently, the trajectories of points of the state space. The basic concepts of topological dynamics are minimality, transitivity, recurrence, shadowing property, stability, equicontinuity, sensitivity, attractors, and topological entropy. Symbolic dynamics studies dynamical systems whose state spaces are zero-dimensional and consist of sequences of symbols. The main classes of symbolic dynamical systems are adding machines, subshifts of finite type, sofic subshifts, Sturmian, substitutive and Toeplitz subshifts, and cellular automata.

This item will also be of interest to those working in geometry and topology.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Dynamical systems; Topological dynamics; Symbolic dynamics; Minimal symbolic systems; Cellular automata; Sets, spaces and numbers; Main theorems; Bibliography; Notation; Index.

Cours Spécialisés—Collection SMF, Number 11

December 2003, 315 pages, Softcover, ISBN 2-85629-143-0, 2000 *Mathematics Subject Classification*: 54H20, 22C05, 34D45, **Individual member $71**, List $79, Order code COSP/11N

Discrete Mathematics and Combinatorics

Stefan Felsner
Geometric Graphs and Arrangements
Some Chapters from Combinatorial Geometry
Advanced Lectures in Mathematics

Geometric Graphs and Arrangements

Some Chapters from Combinatorial Geometry

Stefan Felsner, *Technische Universität Berlin, Germany*

Among the intuitively appealing aspects of graph theory is its close connection to drawings and geometry. The development of computer technology has become a source of motivation for reconsidering these connections, in particular, geometric graphs are emerging as a new subfield of graph theory. Arrangements of points and lines are the objects for many challenging problems and surprising solutions in combinatorial geometry. This book is a collection of beautiful and some very recent results at the intersection of geometry, graph theory, and combinatorics. It is suitable for graduate students and research mathematicians interested in discrete mathematics and combinatorics.

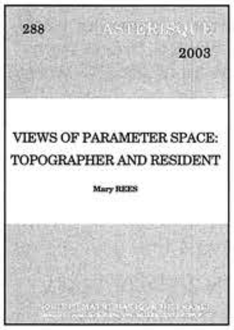
A publication of Vieweg Verlag. The AMS is exclusive distributor in North America. Vieweg Verlag Publications are available worldwide from the AMS outside of Germany, Switzerland, Austria, and Japan.

Contents: Geometric graphs: Turán problems; Schnyder Woods or how to draw a planar graph?; Topological graphs: Crossing lemmas and applications; k-sets and k-facets; Combinatorial problems for sets of points and lines; Combinatorial representations of arrangements of pseudolines; Triangulations and flips; Rigidity and pseudo-triangulations; Bibliography; Index.

Vieweg Advanced Lectures in Mathematics

February 2004, 170 pages, Hardcover, ISBN 3-528-06972-4, 2000 *Mathematics Subject Classification*: 05-01, 05C10, 05C62, 52C10, 52C30, **All AMS members $32**, List $35.80, Order code VWALM/10N

Geometry and Topology



Views of Parameter Space: Topographer and Resident

Mary Rees, *University of Liverpool, UK*

In this work, the author investigates the structure of certain parameter spaces. The aim is to understand the variation of dynamics—in particular, of hyperbolic dynamics—in certain parameter spaces of rational maps. In order to do this, she examines the topological and geometric structure of larger parameter spaces, of branched coverings of the Riemann sphere $\overline{\mathbb{C}}$, where some of the critical points are constrained to have finite forward orbits.

Obtained is a complete topological description of the spaces under consideration, from two points of view, which are called the *Topographer's View* and the *Resident's View*. The *Topographer's View* is, in essence, a geometrizing theorem. It shows that the space in question is, up to homotopy equivalence, a countable union of disjoint geometric pieces, joined together by handles. The most typical geometric pieces are varieties of rational maps and tori. The *Resident's View* is a view of the whole parameter space from the dynamical plane of a map (a resident) in the parameter space. This is necessarily a two-dimensional view, in which the geometric pieces of the parameter space appear as disjoint convex regions in the dynamical plane.

This volume is suitable for graduate students and research mathematicians interested in geometry and topology.

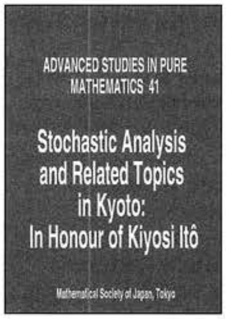
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: *Part I. Topology, Combinatorics, Views:* Introduction; The topology of spaces of homeomorphisms and branched coverings; Loop sets satisfying the invariance and Levy conditions; Nodes, edges and enhanced Levy sets; The group of an enhanced Levy set; Graphs of topological spaces and the topographer's and resident's views; An iteration on a Teichmüller space; How to approach the topographer's and resident's views; *Part II. Teichmüller Distance:* L^1 estimates on the distortion and the first derivative of Teichmüller distance; Product structure in the thin part of Teichmüller space and Teichmüller distance; The formula for the second derivative of Teichmüller distance; Solving the second derivative equation; The second derivative of Teichmüller distance is continuous; The second derivative and the solution of a differential equation; Distance between geodesics; Triangles of geodesics; Hard same shape; *Part III. Proof of the Topographer's View:* Distance and the pullback map; Pushing the pullback map; Pushing and the good vector field; Construction of the good vector field: Part 1; Construction of the good vector field: Part 2; Proof of descending points: Strategy; Proof of descending points: Reductions; Proof of descending points: Critical points; *Part IV. Proof of the Resident's View:* Resident's view of rational maps space: Outline proof; Reductions to the infinity condition theorem; Proof of the infinity condition theorem; Reductions in the proof of the eventually close theorem; Chunks; Outline construction of a good sequence; Straightening; Bibliography.

Astérisque, Number 288

December 2003, 418 pages, Softcover, ISBN 2-85629-144-9, 2000 *Mathematics Subject Classification*: 37J40, 37J50, 32H50, 57Nxx, 57N16, **Individual member $104**, List $115, Order code AST/288N

Probability


ADVANCED STUDIES IN PURE MATHEMATICS 41
Stochastic Analysis and Related Topics in Kyoto: In Honour of Kiyosi Itô
Mathematical Society of Japan, Tokyo

Stochastic Analysis and Related Topics in Kyoto: In Honour of Kiyosi Itô

Hiroshi Kunita, *Nanzan University, Nagoya, Japan*, **Shinzo Watanabe**, *Ritsumeikan University, Kyoto, Japan*, and **Yoichiro Takahashi**, *RIMS, Kyoto University, Japan*, Editors

This volume is a collection of research and survey papers written by invited lecturers at the RIMS international symposium on stochastic analysis and related topics in celebration of Professor Kiyosi Itô's eighty-eighth birthday. Leading stochastic analysts, including his colleagues and former students, attended the symposium and contributed articles to this collection. Readers will find here many new and exciting developments.

The symposium consisted of four sections, which are represented in this volume: "Markov Processes", "Mathematical Finance", "Malliavin Calculus", and a special session on "Perspectives in Stochastic Analysis". Topics covered include quadratic Wiener functionals, representation of martingales, infinite dimensional hypoelliptic semi-group, Orlicz norm equivalence, noises associated with Harris flows, Itô's construction procedure, Stieltjes exponential, stochastic Newton equation, cubic Schröodinger equations, stochastic porous media equation, homogenization on fractals, risk-sensitive portfolio optimization, least square approximation, and more. The book is suitable for graduate students and research mathematicians interested in probability theory and mathematical finance.

Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Contents: H. Airault and **P. Malliavin**, Backward regularity for some infinite dimensional hypoellptic semi-groups; **G. Da Prato** and **M. Röckner**, Invariant measures for a stochastic porous medium equation; **K. D. Elworthy**, **Y. Le Jan**, and **X.-M. Li**, Equivariant diffusions on principal bundles; **D. Feyel** and **A. S. Üstünel**, Monge-Kantorovitch measure transportation, Monge-Ampère equation and the Itô calculus; **M. Fukushima**, Function spaces and symmetric Markov processes; **R. Getoor**, Gauge theorems for Stieltjes exponentials; **T. Hida**, A frontier of white noise analysis, in line with Itô calculus; **M. Hino**, Integral representation of linear functionals on vector lattices and its application to BV functions on Wiener space; **C. Hou** and **I. Karatzas**, Least-squares approximation of random variables by stochastic integrals; **N. Ikeda** and **S. Taniguchi**, Quadratic Wiener functionals, Kalman-Bucy filters, and the KdV equation; **T. Kumagai**, Homogenization on finitely ramified fractals; **H. Kunita**, Representation of martingales with jumps and applications to mathematical finance; **S. Kusuoka**, Stochastic Newton equation with reflecting boundary condition; **H. P. McKean**, Cubic Schrödinger: The petit canonical ensemble; **H. Nagai**, Risk-sensitive portfolio optimization with full and partial information; **J. Sekine**, An approximation for exponential hedging; **I. Shigekawa**, Orlicz norm equivalence for the Ornstein-Uhlenback operator; **D. W. Stroock**, Some comments about Itô's construction procedure; **M. Takeda** and **K. Tsuchida**, Criticality of generalized Schrödinger operators and differentiability of spectral functions; **J. Warren** and **S. Watanabe**, On spectra of noises associated with Harris flows.

Advanced Studies in Pure Mathematics, Volume 41

February 2004, 390 pages, Hardcover, ISBN 4-931469-26-4, 2000 *Mathematics Subject Classification*: 60Hxx; 22Exx, 31Cxx, 35Pxx, 37Kxx, 46Exx, 46Gxx, 47Dxx, 49Mxx, 58Exx, 58Jxx, 60Gxx, 60Jxx, 82Bxx, 82Cxx, 91Bxx, 93Cxx, **All AMS members $83**, List $104, Order code ASPM/41N

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Duties: The director's responsibilities include: scientific activities (planning with the help of the scientific advisory committee, organization and coordination with

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Upcoming deadlines for classified advertising are as follows: February 2004 issue–November 21, 2003; March 2004 issue–December 29, 2003; April 2004 issue–January 28, 2004; May 2004 issue–February 27, 2004; June/July 2004 issue–April 29, 2004; August 2004 issue–May 28, 2005

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Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to classads@ams.org. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

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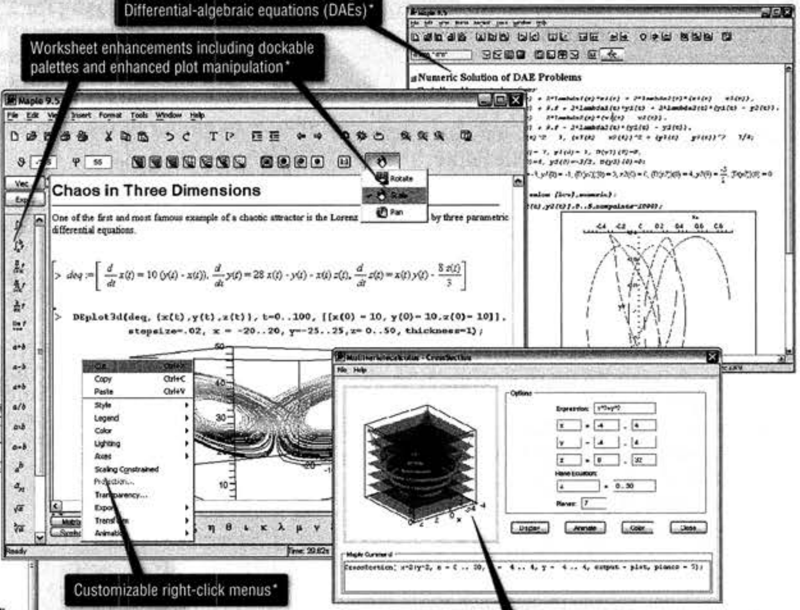
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```
> DEplot3d(deq, {x(t),y(t),z(t)}, t=0..100, [[x(0) = 10, y(0)= 10,z(0)= 10]],
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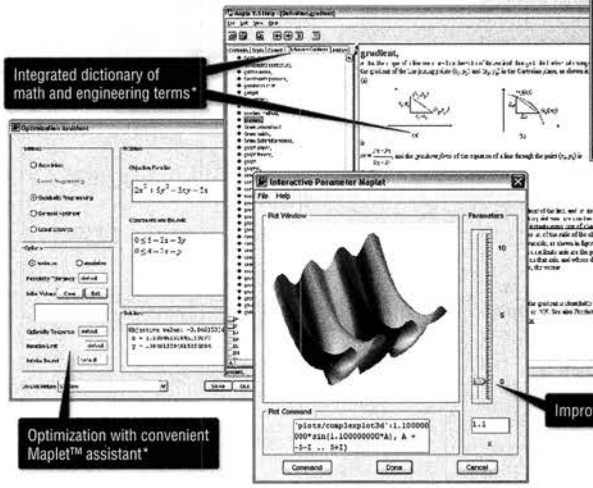
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THE THIRD INTERNATIONAL CONGRESS OF CHINESE MATHEMATICIANS

ICCM2004
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The International Congress of Chinese Mathematicians (ICCM) is a triennial congress hosted by institutions in Mainland China, Taiwan, and Hong Kong in a rotating basis. The previous two congresses were successfully held in Beijing (1998) and Taipei (2001) with around 500 participants from all over the world. One of the highlights of the Congresses is the award of the Morningside Medals of Mathematics and the Chern Prize. Awardees are selected by a panel of international renowned mathematicians with the aim to encourage outstanding mathematicians of Chinese descent in their pursuit of mathematical truth.

The Third ICCM (ICCM2004) will be held in Hong Kong in December 2004. There will be 25 plenary lectures and special sessions on topics in Algebraic Geometry, Applied Analysis, Complex Geometry, Geometric Analysis, Number Theory and Automorphic Form, Mathematical Physics, Mathematical Biology, Numerical Analysis, Probability and Statistics, Waves and Hyperbolic PDE, Wavelets and Fractals, as well as Mathematics Education. Besides the invited lectures, there will also be contributed and poster sessions. To make the congress a true worldwide gathering, non-Chinese mathematicians are also welcome and all presentations will be given in English.

The Morningside Center of Mathematics (MCM) at the Chinese Academy of Sciences, The Institute of Mathematical Sciences (IMS) at The Chinese University of Hong Kong, and the Center of Mathematical Sciences (CMS) at Zhejiang University have been heavily involved with the organization of ICCMs. The Congress Chairman, Professor Shing-Tung Yau, is the director of these Institutes.

The MCM is co-directed by Prof. Lo Yang. It has become one of leading research centers in mathematics in China and a base for many foreign leading mathematicians to communicate and exchange ideas with their countparts in China. It has six academic programs annually in major frontiers of mathematical researches and has successfully trained many young prominent mathematicians in various fields all over China. Its website is **www.mcm.ac.cn**.

The Associate Director at IMS is Prof. Zhouping Xin. The Institute aims to promote mathematical research and to nurture young scientists. It sponsors various special programs, international conferences and workshops in all frontiers of mathematics; its visiting member program accommodates more than 60 visitors annually. It also has a strong Ph.D program in both pure and applied mathematics in cooperation with the Mathematics Department. Its website is **www.ims.cuhk.edu.hk**.

The Executive Director at CMS is Prof. Kefeng Liu. The main tasks of CMS are to organize high-level academic activities, carry out first-class original innovative research, and train young mathematics talents. Its goal is to establish itself as a first class research center in the world. Its website is **cms.zju.edu.cn**.

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Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Programs and abstracts will continue to be displayed on the AMS website in the Meetings and Conferences section until about three weeks after the meeting is over. Final programs for Sectional Meetings will be archived on the AMS website in an electronic issue of the *Notices* as noted below for each meeting.

Nashville, Tennessee

Vanderbilt University

October 16–17, 2004

Saturday - Sunday

Meeting #999

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: August 2004
Program first available on AMS website: September 2, 2004
Program issue of electronic *Notices*: October 2004
Issue of *Abstracts*: Volume 25, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: June 29, 2004
For abstracts: August 24, 2004

Invited Addresses

Ruth M. Charney, Brandeis University, *Title to be announced.*

Peter S. Ozsvath, Columbia University, *Title to be announced.*

Sorin T. Popa, University of California Los Angeles, *Title to be announced.*

Rudi Weikard, University of Alabama at Birmingham, *Title to be announced.*

Special Sessions

Algebraic Geometry and Commutative Algebra (Code: SS 8A), **Juan C. Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Biomathematics (Code: SS 12A), **Laurent Pujo-Menjouet** and **Glenn F. Webb**, Vanderbilt University.

Geometry of Hyperbolic Manifolds (Code: SS 10A), **John G. Ratcliffe** and **Steven T. Tschantz**, Vanderbilt University.

Index Theory and the Topology of Manifolds (Code: SS 3A), **Bruce Hughes** and **Guoliang Yu**, Vanderbilt University.

Inverse Problems (Code: SS 9A), **Maeve L. McCarthy**, Murray State University, and **Rudi Weikard**, University of Alabama at Birmingham.

Local and Homological Algebra (Code: SS 6A), **Florian Enescu**, University of Utah, and **Adela N. Vraciu**, University of South Carolina.

Nonlinear Partial Differential Equations and Applications (Code: SS 11A), **Gieri Simonett**, Vanderbilt University.

Operator Theory on Function Spaces (Code: SS 7A), **Dechao Zheng**, Vanderbilt University.

Semigroup Theory (Code: SS 13A), **Matthew I. Gould**, Vanderbilt University, and **Karen Ann Linton**, California State Polytechnic University, Pomona.

Topological Aspects of Group Theory (Code: SS 5A), **Michael L. Mihalik** and **Mark V. Sapir**, Vanderbilt University.

Universal Algebra and Lattice Theory (Code: SS 4A), **Ralph N. McKenzie**, Vanderbilt University, and **George F. McNulty**, University of South Carolina.

Von Neumann Algebras and Noncommutative Ergodic Theory (Code: SS 1A), **Dietmar Bisch**, Vanderbilt University, and **Sorin T. Popa**, University of California Los Angeles.

Wavelets, Frames, and Sampling (Code: SS 2A), **Akram Aldroubi** and **Douglas P. Hardin**, Vanderbilt University, and **Qiyu Sun**, University of Central Florida.

Albuquerque, New Mexico

University of New Mexico

October 16–17, 2004

Saturday – Sunday

Meeting #1000

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2004
Program first available on AMS website: September 3, 2004
Program issue of electronic *Notices*: October 2004
Issue of *Abstracts*: Volume 25, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: June 29, 2004
For abstracts: August 24, 2004

Invited Addresses

Sara C. Billey, University of Washington, Seattle, *Title to be announced.*

Peter Ebenfelt, University of California San Diego, *Title to be announced.*

Theodore Stanford, New Mexico State University, *Title to be announced.*

Craig A. Tracy, University of California Davis, *Title to be announced.*

Special Sessions

Algebraic Geometry (Code: SS 3A), **Hirotachi Abo** and **Chris Peterson**, Colorado State University.

Analysis and Geometry in Carnot-Caratheodory Spaces (Code: SS 13A), **Luca Capogna**, University of Arkansas, and **Robert Smits**, New Mexico State University.

Arithmetic Geometry (Code: SS 6A), **Alexandru Buium** and **Michael J. Nakamaye**, University of New Mexico.

Braids and Knots (Code: SS 14A), **Theodore Stanford**, New Mexico State University.

Categories and Operads in Topology, Geometry, Physics and Other Applications (Code: SS 5A), **Hanna Ewa Makaruk** and **Robert Michal Owczarek**, Los Alamos National Laboratory, and **Zbigniew Oziewicz**, Universidad Nacional Autónoma de México.

Financial Mathematics: The Mathematics of Derivative Securities (Code: SS 4A), **Maria Cristina Mariani**, New Mexico State University, and **Osvaldo Mendez**, University of Texas at El Paso.

Interactions in Riemannian Geometry (Code: SS 8A), **Charles P. Boyer** and **Krzysztof Galicki**, University of New Mexico.

Mathematical Methods in Turbulence (Code: SS 9A), **Monika Nitsche** and **Vachtang Poutkaradze**, University of New Mexico.

Mathematics for Secondary Teachers: Curriculum and Assessment (Code: SS 16A), **Adriana Aceves** and **Kristin Umland**, University of New Mexico.

Multiscale Methods and Sampling in Time-Frequency Analysis (Code: SS 10A), **Jeffrey Andrew Hogan**, University of Arkansas, and **Joseph D. Lakey**, New Mexico State University.

Nonlinear Partial Differential Equations Applied to Materials Science (Code: SS 11A), **Patricia Bauman**, Purdue University, and **Tiziana Giorgi**, New Mexico State University.

Probabilistic and Geometric Methods in Learning Theory (Code: SS 15A), **Vladimir Koltchinskii**, University of New Mexico.

Random Matrix Theory and Growth Processes (Code: SS 1A), **Craig A. Tracy**, University of California Davis.

Regularity in PDEs and Harmonic Analysis (Code: SS 12A), **Marianne Korten** and **Charles Nelson Moore**, Kansas State University, and **Maria C. Pereyra**, University of New Mexico.

Several Complex Variables and CR Geometry (Code: SS 2A), **Peter Ebenfelt**, University of California San Diego, and **Marshall A. Whittlesey**, California State University, San Marcos.

Spectral Geometry (Code: SS 7A), **Ivan G. Avramidi**, New Mexico Institute of Mining and Technology, and **Thomas Patrick Branson**, University of Iowa.

Evanston, Illinois

Northwestern University

October 23–24, 2004

Saturday – Sunday

Meeting #1001

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2004
Program first available on AMS website: September 9, 2004
Program issue of electronic *Notices*: October 2004
Issue of *Abstracts*: Volume 25, Issue 4

Deadlines

For organizers: Expired

For consideration of contributed papers in Special Sessions: July 7, 2004
For abstracts: August 31, 2004

Invited Addresses

Ian Agol, University of Illinois at Chicago, *Title to be announced.*

Robert W. Ghrist, University of Illinois, *Title to be announced.*

Yuri Manin, Northwestern University, *Title to be announced.*

Paul Seidel, Imperial College-London and University of Chicago, *Title to be announced.*

Special Sessions

Algebraic Representations and Deformations (Code: SS 19A), **Stephen R. Doty** and **Anthony Giaquinto**, Loyola University of Chicago.

Algebraic Topology: Interactions with Representation Theory and Algebraic Geometry (Code: SS 13A), **Paul G. Goerss**, Northwestern University, **Jesper Kragh Grodal**, University of Chicago, and **Brooke E. Shipley**, University of Illinois at Chicago.

Applications of Motives (Code: SS 18A), **Eric M. Friedlander**, Northwestern University, **Alexander Goncharov**, Brown University, **Mikhail Kapranov**, Yale University, and **Yuri Manin**, Max Planck Institute for Mathematics.

Codes and Applications (Code: SS 5A), **William C. Huffman**, Loyola University of Chicago, and **Vera S. Pless**, University of Illinois at Chicago.

Computability Theory and Applications (Code: SS 8A), **Robert I. Soare** and **Denis R. Hirschfeldt**, University of Chicago.

Differential Geometry (Code: SS 10A), **Anders Ingemar Linner** and **Hongyou Wu**, Northern Illinois University.

Extremal Combinatorics (Code: SS 2A), **Dhruv Mubayi** and **Yi Zhao**, University of Illinois at Chicago.

Fluid Dynamics, Diffusion and Reaction (Code: SS 4A), **Peter S. Constantin** and **Leonid V. Ryzhik**, University of Chicago.

Geometric Aspects of the Langlands Program (Code: SS 17A), **Edward Frenkel**, University of California Berkeley, **Mark Goresky**, Institute for Advanced Study, and **Kari Vilonen**, Northwestern University.

Geometric Partial Differential Equations (Code: SS 7A), **Gui-Qiang Chen** and **Jared Wunsch**, Northwestern University.

Hopf Algebras at the Crossroads of Algebra, Category Theory, and Topology (Code: SS 24A), **Louis H. Kauffman** and **David E. Radford**, University of Illinois at Chicago, and **Fernando J. O. Souza**, University of Iowa.

Index Theory, Morse Theory, and the Witten Deformation Method (Code: SS 3A), **Igor Prokhorenkov** and **Ken Richardson**, Texas Christian University.

Iterated Function Systems and Analysis on Fractals (Code: SS 12A), **Ka-Sing Lau**, Chinese University of Hong Kong, and **Stephen S.-T. Yau**, University of Illinois at Chicago.

Low-Dimensional Topology and Kleinian Groups (Code: SS 21A), **Ian Agol**, **John Holt**, and **Saul Schleimer**, University of Illinois at Chicago.

Mathematical Problems in Robotics (Code: SS 15A), **Robert W. Ghrist**, University of Illinois at Urbana-Champaign.

Mathematical Techniques in Musical Analysis (Code: SS 23A), **Judith Baxter**, University of Illinois at Chicago, **Richard Cohn**, University of Chicago, and **Robert Peck**, Louisiana State University.

Modern Schubert Calculus (Code: SS 1A), **Ezra Miller**, University of Minnesota, and **Frank Sottile**, University of Massachusetts.

Nonlinear Partial Differential Equations and Applications (Code: SS 6A), **Gui-Qiang Chen**, Northwestern University, and **Mikhail Feldman**, University of Wisconsin at Madison.

Nonlinear Waves (Code: SS 14A), **Jerry L. Bona**, University of Illinois at Chicago, **Shuming Sun**, Virginia Polytechnic Institute and State University, and **Bingyu Zhang**, University of Cincinnati.

Representation Theory of Reductive Groups (Code: SS 20A), **Jeffrey D. Adler**, University of Akron, and **Ju-Lee Kim**, University of Illinois at Chicago.

Solving Polynomial Systems (Code: SS 9A), **Anton Leykin** and **Jan Verschelde**, University of Illinois at Chicago.

Special Functions, Orthogonal Polynomials, and Their Applications (Code: SS 22A), **George Gaspar**, Northwestern University, and **Ahmed I. Zayed**, DePaul University.

Spectral Problems of Differential Operators (Code: SS 16A), **Qingkai Kong**, **Hongyou Wu**, and **Anton Zettl**, Northern Illinois University.

Stability Issues in Fluid Dynamics (Code: SS 11A), **Susan J. Friedlander** and **Roman Shvydkoy**, University of Illinois at Chicago.

Pittsburgh, Pennsylvania

University of Pittsburgh

November 6–7, 2004

Saturday – Sunday

Meeting #1002

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: September 2004
Program first available on AMS website: September 23, 2004
Program issue of electronic *Notices*: November 2004
Issue of *Abstracts*: Volume 25, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: July 20, 2004

For abstracts: September 14, 2004

Invited Addresses

Jeffrey F. Brock, Brown University, *Title to be announced.*

Der-Chen Chang, Georgetown University, *Title to be announced.*

Robert Schapire, Princeton University, *Title to be announced.*

Ofer Zeitouni, University of Minnesota, Minneapolis, *Title to be announced.*

Special Sessions

Convexity and Combinatorics (Code: SS 2A), **James F. Lawrence** and **Valeriu Soltan**, George Mason University.

Geometric Analysis and Partial Differential Equations in Subelliptic Structures (Code: SS 12A), **Cristian E. Gutíerrez**, Temple University, **Guozhen Lu**, Wayne State University, and **Juan J. Manfredi**, University of Pittsburgh.

Graph Polynomials (Code: SS 8A), **E. Glen Whitehead Jr.**, University of Pittsburgh.

The History of Mathematics (Code: SS 3A), **Robert E. Bradley**, Adelphi University, and **Lawrence A. D'Antonio**, Ramapo College of New Jersey.

Invariants of Knots and 3-Manifolds (Code: SS 1A), **Marta M. Asaeda**, University of Maryland, **Jozef H. Przytycki**, George Washington University, and **Adam S. Sikora**, SUNY at Buffalo.

Knots and Macromolecules (Code: SS 7A), **Kenneth C. Millett**, University of California Santa Barbara, and **Eric J. Rawdon**, Duquesne University.

Mathematical Biology (Code: SS 13A), **Jonathan E. Rubin** and **Bard Ermentrout**, University of Pittsburgh.

Mathematical Finance (Code: SS 11A), **David Saunders** and **John Chadam**, University of Pittsburgh.

Mathematical Modeling of Nonlinear Phenomena in Biology and Mechanics (Code: SS 6A), **Anna Vainchtein** and **William C. Troy**, University of Pittsburgh.

Modularity of Galois Representations and Serre's Conjecture (Code: SS 14A), **Mark E. T. Dickinson**, University of Pittsburgh.

Multiscale Algorithms in Computational Fluid Dynamics (Code: SS 5A), **William J. Layton**, University of Pittsburgh, and **Anastasios Liakos**, U.S. Naval Academy.

Multivariate Hypergeometric Functions: Combinatorial and Algebro-Geometric Aspects (Code: SS 9A), **Eduardo Cattani**, University of Massachusetts, Amherst, **Alicia M. Dickenstein**, Universidad de Buenos Aires, and **Laura Felicia Matusevich**, Harvard University.

Partial Differential Equations and Applications (Code: SS 4A), **Xinfu Chen** and **Dehua Wang**, University of Pittsburgh.

PDE-Based Methods in Imaging and Vision (Code: SS 15A), **Stacey E. Levine**, Duquesne University, and **Yunmei Chen**, University of Florida.

Trends in Operator Theory and Banach Spaces (Code: SS 10A), **Christopher J. Lennard** and **Thomas A. Metzger**, University of Pittsburgh.

Atlanta, Georgia

Atlanta Marriott Marquis and Hyatt Regency Atlanta

January 5–8, 2005

Wednesday – Saturday

Meeting #1003

Joint Mathematics Meetings, including the 111th Annual Meeting of the AMS, 88th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association of Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL).
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: October 2004
Program first available on AMS website: November 1, 2004
Program issue of electronic *Notices*: January 2005
Issue of *Abstracts*: Volume 26, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: August 10, 2004
For abstracts: October 5, 2004
For summaries of papers to MAA organizers: September 14, 2004

Joint Invited Addresses

Andrea L. Bertozzi, University of California Los Angeles, *Title to be announced* (AMS-MAA Invited Address).

Bernd Sturmfels, University of California Berkeley, *Title to be announced* (AMS-MAA Invited Address).

AMS Invited Addresses

Ingrid Daubechies, Princeton University, *Title to be announced* (AMS Josiah Willard Gibbs Lecture).

Eleny Ionel, University of Wisconsin, *Title to be announced.*

Bruce A. Kleiner, University of Michigan, Ann Arbor, *Title to be announced.*

Robert K. Lazarsfeld, University of Michigan, *Title to be announced* (AMS Colloquium Lectures).

Gunther Uhlmann, University of Washington, *Title to be announced.*

Avi Wigderson, Institute for Advanced Study, *Title to be announced.*

Steven M. Zelditch, Johns Hopkins University, *Title to be announced.*

MAA Invited Addresses

Georgia Benkart, University of Wisconsin, Madison, *Title to be announced.*

Erik D. Demaine, Massachusetts Institute of Technology, *Title to be announced.*

Fernando Q. Gouvêa, Colby College, *Title to be announced.*

Steven G. Krantz, Washington University, *Title to be announced.*

Ravi D. Vakil, Stanford University, *Title to be announced.*

Robin J. Wilson, The Open University, *Title to be announced.*

Invited Addresses of Other Organizations

Pavel Pevzner, University of California San Diego, *Title to be announced* (SIAM).

Call for MAA Contributed Papers

The organizers listed below solicit contributed papers pertinent to their sessions. Sessions generally limit presentations to ten minutes, but selected participants may extend their contributions up to twenty minutes. Please see the limits on multiple author submissions as described at the end of this announcement. Each session room contains an overhead projector and screen; blackboards will not be available. Persons needing additional equipment should contact as soon as possible but prior to September 14, 2004, the session organizer whose name is followed by an asterisk (*). Please note that the dates and times scheduled for these sessions remain tentative.

Getting Students to Discuss and to Write about Mathematics (MAA CP A1), Wednesday morning and Thursday afternoon; **Sarah L. Mabrouk***, Framingham State College (`mabrouk@frc.mass.edu`). This session invites papers about assignments and projects that require students to communicate mathematics through in-class oral presentations, in-class discussions that they must lead and motivate, and written assignments and/or papers. These assignments/projects can include analysis and applications of mathematics, presentations of and analysis of proofs, presentations about famous mathematicians and the mathematics that they studied, and assignments/projects that utilize creative writing. Presenters are encouraged to discuss how the use of the assignment/project helps the student to gain greater understanding of mathematics as well as to improve his/her understanding of mathematics language and his/her ability to communicate mathematics. Of particular interest is the effect of such projects/assignments/presentations throughout the course on the student's understanding of mathematics, his/her communication of mathematics, and his/her attitude toward mathematics.

My Favorite Demo: Innovative Strategies for Mathematics Instructors (MAA CP B1), Wednesday morning and Thursday afternoon; **David R. Hill***, Temple University (`hill@math.temple.edu`), and **Lila F. Roberts**, Georgia College and State University. Mathematics instructors use a myriad of innovative techniques for teaching mathematical concepts. Technology readily available in colleges and universities has provided a means to boost creativity and flexibility in lesson design. Tools an instructor utilizes may include specialized computer applications, animations and other multimedia tools, java applets, physical devices, games, etc. This contributed paper session will focus on novel demos that mathematics instructors have successfully used in their classrooms. Rather than focus on projects or student group activities, this contributed paper session will focus on the instructor's activities to facilitate learning. Mathematical content areas will include precalculus, calculus, elementary probability, and selected postcalculus topics. This session invites 1) demos that introduce a topic, 2) demos that illustrate how concepts are applicable, 3) demos that tell a story or describe the development of a procedure, and 4) demos that lead to an activity that involves the class. Presenters of demos are encouraged to give the demonstration, if time and equipment allow, and to discuss how to use it in a classroom setting. Proposals should describe how the demo fits into a course, the use of technology or technology requirements, if any, and the effect of the demo on student attitudes toward mathematics.

Courses below Calculus: A New Focus (MAA CP C1), Wednesday morning and Friday afternoon; **Mary Robinson***, University of New Mexico-Valencia Campus (`maryrobn@unm.edu`); **Florence S. Gordon**, New York Institute of Technology; **Laurette B. Foster**, Prairie View A&M University; **Arlene H. Kleinstein**, Farmingdale State University of New York; **Norma M. Agras**, Miami Dade Community College; and **Linda Martin**, Albuquerque T-VI. An unprecedented collaborative effort has been developed among members of the MAA, AMATYC, and NCTM to launch a national initiative to refocus courses below calculus. The goal of the initiative is to encourage development and implementation of courses that place greater emphasis on conceptual understanding and realistic applications of the mathematics. Courses that better motivate students and prepare them to take subsequent mathematics courses, including calculus, statistics, and quantitative methods, are needed to better serve the needs of the quantitative disciplines and prepare students to function effectively in today's workplace, as well as function effectively as citizens in today's increasingly quantitative society. Accordingly, for this session we specifically seek to address all of the college-level courses below calculus, with particular emphasis on offerings in college algebra and precalculus. We seek proposals for presentations that offer new visions for such courses, discuss implementation issues (such as faculty training, placement tests, introduction of alternative tracks for different groups of students, transferability problems, etc.) related to offering such courses, present results of studies on student performance and tracking data in both traditional and new versions of these courses and in follow-up courses, discuss the needs of other disciplines and the workplace from courses at this level, discuss connections to the changing school curricula and implications for teacher education. This session is cosponsored by the CRAFTY, the Committee on Two Year Colleges, and the Committee on Service Courses.

Mathematics and Sports (MAA CP D1), Wednesday morning and Friday afternoon; **Douglas Drinen***, University of the South (`ddrinen@sewanee.edu`); **Sean L. Forman**, St. Joseph's University; **Howard L. Penn**, U.S. Naval Academy. When applied to the sporting arena, mathematics can provide both compelling classroom examples and interesting research problems. Baseball has long been mined for interesting statistics examples, ranging from regression and probability to the game theoretic aspects of in-game strategy. Recent books on jai alai, football, and a few other sports have studied those sports through a mathematical lens. The economics of sports is now covered by its own journal and the statistics publication *Chance* routinely discusses statistical examples from sporting events. This session invites papers describing interesting classroom examples utilizing examples from sports and papers discussing the application of mathematics to sporting events.

Mathematics in the Islamic World (MAA CP E1), Wednesday afternoon; **Glen Van Brummelen***, Bennington College (`gvanbrum@bennington.edu`), and **Victor J. Katz**, University of the District of Columbia. This session solicits presentations on all facets of the history of the mathematical sciences in the Islamic world, including the relationship of Islamic mathematics to Western mathematics and to Indian or Chinese mathematics. We hope to elaborate both the unity and diversity of Muslim contributions to both pure and applied mathematical disciplines.

Mathlets for Teaching and Learning Mathematics (MAA CP F1), Wednesday afternoon; **David M. Strong***, Pepperdine University (`David.Strong@pepperdine.edu`); **Thomas E. Leathrum**, Jacksonville State University; and **Joe Yanik**, Emporia State University. This session seeks to provide a forum in which presenters may demonstrate mathlets and related materials that they have created or further developed. Mathlets are small computer-based (but ideally platform-independent) interactive tools for teaching math, frequently developed as World Wide Web materials such as scripts or Java applets, but there may be many other innovative variations. Mathlets allow students to experiment with and visualize a variety of mathematical concepts, and they can be easily shared by mathematics instructors around the world. The session is sponsored by the MAA Committee on Computers in Mathematics Education (CCIME).

Drawing on Our Students' Thinking to Improve the Mathematical Education of Teachers (MAA CP G1), Wednesday afternoon; **Dale R. Oliver***, Humboldt State University (`dale.oliver@humboldt.edu`), and **Mary Kay Abbey**, Montgomery College. The MET document (*The Mathematical Education of Teachers*, CBMS, 2001) and the PMET project (*Preparing Mathematicians to Educate Teachers*, MAA, 2003–2006) call for mathematics faculty to reexamine what they teach and how they teach in mathematics courses for prospective teachers. A key component of this reexamination is careful consideration of the mathematical understanding and thinking of the prospective teachers in our courses. Doing so informs faculty decisions about curriculum and pedagogy, and directs their instructional effort toward the individuals in the course. This session invites papers on the mathematical preparation of teachers in which what is taught and how it is taught is being informed by the understanding and thinking of the prospective teachers. This session is sponsored by COMET, the MAA Committee on the Mathematical Education of Teachers.

History of Undergraduate Mathematics in America, 1900–2000 (MAA CP H1), Thursday morning; **Jack Winn***, SUNY Farmingdale (`winnja@farmingdale.edu`); **Walter J. Meyer**, Adelphi University; **Joseph Malkevitch**, York College of CUNY; and **Amy E. Shell-Gellasch**, Grafenwoehr, Germany. This session will sketch how the last hundred years or so have led us to today's state of undergraduate mathematics. Questions that are appropriate to discuss include: what curricular changes occurred, how the changes depended on changes in mathematical knowledge, other reasons why changes in teaching occurred, what effects flowed from the changes, and how changes affected student learning. Papers may focus on: important individuals; important movements involving curriculum or styles of instruction, the evolution or disappearance of particular courses, case studies of particular institutions, the history and role of important organizations such as the NSF and the MAA, key events or circumstances external to the mathematical community, etc. The speaker's personal views about the best way to teach certain topics are discouraged, unless those views are part of or help explain historical issues.

Initializing and Sustaining Undergraduate Research Projects and Programs (MAA CP I1), Thursday morning, **Margaret M. Robinson***, Mount Holyoke College (`robinson@mtholyoke.edu`), and **Suzanne M. Lenhart**, University of Tennessee. Papers are requested describing undergraduate research projects, courses, and programs. Of particular interest will be descriptions of innovative ways to get administrative support or other support that creates a sustainable program. Also of interest will be papers indicating where to find appropriate problems and how to gauge the right level. Also, descriptions of courses with undergraduate research as the main goal will be included. This session is sponsored by the CUPM Subcommittee on Undergraduate Research.

Projects and Demonstrations That Enhance a Differential Equations Course (MAA CP J1), Thursday morning; **Richard J. Marchand***, Slippery Rock University (`Richard.Marchand@SRU.edu`), and **Shawnee L. McMurran**, California State University, San Bernardino. Differential equations is a diverse mathematical field that affords educators a great deal of flexibility in terms of content. The course can be highly theoretical, applied, or a combination of both. This session invites novel projects or demonstrations that enhance a differential equations course either through the facilitation of mathematical theory or exposure to interdisciplinary fields. New and interesting case studies are encouraged, especially those that require computational or qualitative techniques. Demonstrations may be virtual, physical, or mathematical. Examples include, but are not limited to, novel proofs, mathlets, or physical demonstrations.

Countering "I Can't Do Math"; Strategies for Teaching Underprepared, Math-Anxious Students (MAA CP K1), Thursday morning, **Suzanne Dorée***, Augsburg College (`doree@augsburg.edu`); **Bonnie Gold**, Monmouth University; and **Richard J. Jardine**, Keene State College. How can we create a comfortable learning environment for underprepared or math-anxious students, and, in particular, how can we constructively assess student learning? What classroom practices are especially effective with such students, and how does research on student learning inform those practices? How might the recommendations of the 2004 CUPM Curriculum Guide influence our approach in teaching developmental or introductory courses to better reach these students? This session invites papers on all aspects of "what works" in teaching underprepared, math-anxious students.

Using Real-World Data to Illustrate Statistical Concepts (MAA CP L1), Thursday afternoon and Friday morning; **Thomas L. Moore***, Grinnell College (`mooret@grinnell.edu`), and **John D. McKenzie Jr.**, Babson College. Guidelines in statistical education emphasize the use of real data instead of the small, contrived data sets that appear in some textbooks. Faculty who have used real-world data to illustrate statistical concepts are invited to submit proposals that describe the data set, its location on the Web, and their use of the data set to teach ideas related to an introductory course in statistics: (1) data collection (sampling, design of experiments, potential biases); (2) data description (numerical summaries, graphical displays); (3) sampling distributions; (4) elementary inference (interval estimation and hypothesis testing); (5) other applications, such as ANOVA, regression, and chi-square tests.

Environmental Mathematics and the Interdisciplinary (MAA CP M1), Friday morning; **Karen Bolinger***, Clarion University (`kbolinge@mail.clarion.edu`); **Ben Fusaro**, Florida State University; and **William Stone**, New Mexico Institute of Mining & Technology. We seek presentations that deal with all aspects of the pedagogy and the modeling of environmental problems suitable for general education, calculus, and above. Readers are invited to take up the challenge of searching the natural sciences, as well as economics, environmental science, and environmental education for problems that can be clarified, extended, or solved by undergraduate mathematics. We encourage contributions that emphasize computational, visual, or qualitative approaches.

Teaching Visualization Skills (MAA CP N1), Friday morning; **Mary L. Platt***, Salem State College (`mplatt@salemstate.edu`); **Catherine A. Gorini**, Maharishi University of Management; and **Sarah J. Greenwald**, Appalachian State University. The ability to understand, use, and create diagrams, graphs, and illustrations is essential for students in every area of mathematics. Computers have made graphics of every form widely available, so there is an increasing need to help students develop their ability to handle visual information. This session invites papers on all aspects of visualization in the college classroom: which skills are needed for success in mathematics, how to train students to use visual information, examples of classroom activities that help develop visualization skills, and ways to assess a student's visualization skills.

Teaching and Assessing Problem Solving (MAA CP O1), Friday morning; **Alex J. Heidenberg***, U.S. Military Academy (`alex.heidenberg@usma.edu`), and **Michael Huber**, U.S. Military Academy. Developing problem-solving skills in the modeling sense is a central component in refocusing courses to emphasize process, conceptual understanding, and student growth. Universities and colleges are now writing institutional goals that address the capabilities of their graduates. How do we measure success in teaching our students to be effective problem solvers? This session invites presentations about courses that focus on the process of problem solving as a vehicle to learning mathematics at the precalculus/introductory calculus levels, with special emphasis on modeling. These presentations can include course composition, philosophy, teaching ideas, and/or past projects, examinations, or other successful methods of assessment where students have become competent and confident problem solvers. Each presentation should address the specific goals in developing problem solvers as well as the assessment techniques used to measure attainment of those goals. In addition, presenters should address how technology (calculators, computer algebra systems, etc.) is incorporated into the teaching plan.

Philosophy of Mathematics (MAA CP P1), Friday afternoon; **Charles R. Hampton***, The College of Wooster (`Hampton@wooster.edu`), and **Bonnie Gold**, Monmouth University. This session, sponsored by the SIGMAA on the Philosophy of Mathematics, invites papers on any topic in the philosophy of mathematics except logic and set theory. Possible topics include the nature of mathematics, the nature of mathematical objects, the nature of mathematical knowledge, the relation between mathematics and the physical world, the role of esthetics in the development of mathematics.

Using Handheld Technology to Facilitate Student-Centered Teaching/Learning Activities at the Developmental Algebra Level (MAA CP Q1), Friday afternoon; **Ed Laughbaum***, The Ohio State University (`elaughba@math.ohio-state.edu`), and **Maria DeLucia**, Middlesex County College. Lecture is the predominate method of choice for teaching remedial-level algebra, but handheld graphing devices are often integrated by faculty. However, in many cases the teaching/learning is still instructor centered. Handheld devices offer the flexibility of enhancing teaching and learning through student-centered activities, which can be used outside of class or during class through group work. Anecdotal evidence shows developmental algebra teachers often supplement textbook materials with "graphing calculator" activities because even "reform" textbooks do not offer appropriate ancillary packages. Therefore, we invite developmental algebra faculty to submit proposals on creative teaching/learning activities that are student centered, provide a diverse learning environment, offer options for learning and teaching, and use handheld devices.

My Three Favorite Original Calculus Problems (MAA CP R1), Saturday morning; **J. D. Phillips***, Wabash College (`phillipj@wabash.edu`), and **Timothy J. Pennings**, Hope College. This session is for those who, while teaching single and multivariable calculus over the years, have thought of a few clever or novel problems with solid pedagogical value that they would like to share with others. In particular, we are looking for original problems suitable for homework assignments or challenging test questions. (We are not looking for extended modeling projects and open-ended problems, since good collections of these already exist.) We hope to organize these into a booklet for publication, which could be used as a resource for calculus courses. Thus, we ask that each submission adhere to the following template: (i) statement of the problem, (ii) brief explanation of why it is interesting and pedagogically valuable, (iii) complete solution leading to an answer in closed form. Submissions may include from two to four problems. Participants should bring copies of their problems to the session for distribution. Each problem should begin on a new page. To include as many as possible, each participant will be given 10 minutes for presentation of the problems.

Meeting the Challenge: Relationship between Mathematics and Biology in the 21st Century (MAA CP S1), Saturday morning; **Catherine M. Murphy***, Purdue University Calumet (`murphycm@calumet.purdue.edu`); **G. Elton Graves**, Rose Hulman Institute of Technology; and **David A. Smith**, Duke University. "Biology as Information", the title of the 2004 Gibbs Lecture by Eric S. Lander, professor of biology at MIT, emphasizes the fundamental changes that the science of biology is undergoing, especially in the connections between biology and mathematics that are of necessity becoming broader and deeper. This contributed paper session will provide a forum for mathematicians with experience working at the interface of mathematics and biology to present papers that discuss the mathematics needed by contemporary biologists, the opportunities for mathematicians and biologists to collaborate in teaching, curriculum development, student research projects, or professional research. Talks especially valued are those that make practical suggestions concerning how to establish fruitful communication between mathematicians and biologists and how to stimulate mathematics and biology students to prepare themselves to participate in this swiftly changing field. This session is sponsored by the Subcommittee on Mathematics Across the Disciplines.

Mathematics Experiences in Business, Industry and Government (MAA CP T1), Saturday morning; **Philip E. Gustafson***, Mesa State College (`pgustafs@mesastate.edu`), and **Michael G. Monticino**, University of North Texas. This contributed paper session will provide a forum for mathematicians with experience in Business, Industry and Government (BIG) to present papers or discuss projects involving the application of mathematics to BIG problems. BIG mathematicians, as well as faculty and students in academia who are interested in learning more about BIG practitioners, projects, and issues, will find this session of interest. This session is sponsored by the MAA Business, Industry and Government Special Interest Group (BIG SIGMAA).

Mathematical Experiences for Students outside the Classroom (MAA CP U1), Saturday afternoon; **Kay B. Somers***, Moravian College (`somersk@moravian.edu`), and **Jody M. Sorensen**, Grand Valley State University. Mathematics "happens" both inside and outside the classroom, and, in fact, many mathematics majors are drawn to the subject through a special event sponsored by a student chapter or math club. This session seeks presentations by academic, industrial, business, and/or student mathematicians so that the audience will be encouraged to organize and run special events for their students. Descriptions of nonclassroom activities could include, but are not limited to, special lectures, workshops for students, math days, math fairs, research projects for students, math career days, student conferences, recreational mathematics activities, problem-solving activities and contests, general community-building activities, and student consulting projects. Information on how such activities are organized and carried out, what activities especially grab students' interests, how students are contacted and encouraged to participate, and how the events are funded will be especially helpful. This session is organized by the MAA Committee on Undergraduate Student Activities and Chapters.

Research on the Teaching and Learning of Undergraduate Mathematics (MAA CP V1), Saturday afternoon; **William O. Martin***, North Dakota State University (`william.martin@ndsu.nodak.edu`); **Barbara E. Edwards**, Oregon State University; and **Draga D. Vidakovic**, Georgia State University. Research papers that address issues concerning the teaching and learning of undergraduate mathematics are invited. Appropriate for this session are theoretical or empirical investigations conducted within clearly defined theoretical frameworks, using either qualitative or quantitative methodologies. Of highest priority are proposals that report on completed studies that further existing work in the field.

In-Service Training Programs for K–12 Mathematics Teachers (MAA CP W1), Saturday afternoon; **Zsuzsanna Szaniszlo***, Valparaiso University (`zsuzsanna.szaniszlo@valpo.edu`); **Judith L. Covington**, Louisiana State University, Shreveport; and **Tamas Szabo**, Weber State University. All over the country many small- and large-scale projects exist to provide in-service training for K–12 mathematics teachers. The directors of these projects will share their experiences developing and implementing the projects, including both mathematical and organizational issues. Mathematicians contemplating starting similar projects will be able to learn about successful strategies and potential pitfalls for these outreach activities. The session invites talks that showcase successful in-service training programs for K–12 mathematics teachers. The talks should reflect on every aspect of the program, including funding sources, organizational details, information on cooperation with the school districts, mathematical content and methodology, follow-up, evaluation and dissemination. Programs that are easily replicable will be given priority.

General Contributed Paper Session (MAA CP X1), Wednesday, Thursday, Friday, Saturday mornings and afternoons; **Daniel E. Otero***, Xavier University (`otero@xavier.xu.edu`). Papers may be presented on any mathematical topic. Papers that fit into one of the other sessions should be sent to that organizer, not to this session.

Submission Procedures for MAA Contributed Papers

Send your abstract directly to the AMS. At the same time, send a detailed one-page summary of your paper directly via email to the organizer, indicated with an asterisk (*). To enable the organizer to evaluate the appropriateness of your paper, include as much detailed information as possible within the one-page limitation. The summary need not duplicate the information in the abstract. Participants may speak in at most two MAA contributed paper sessions. If your paper cannot be accommodated in the session for which it was submitted, it will be automatically considered for the general session. Speakers may give only one presentation in the general session because of time/space limitations. A proposal should not be sent to more than one organizer. The summary must reach the organizer by Tuesday, September 14, 2004. Abstracts must reach the AMS by Tuesday, October 5, 2004.

The AMS will publish abstracts for the talks in the MAA sessions. Abstracts must be submitted electronically to the AMS. No knowledge of LaTeX is necessary; however, LaTeX and AMS-LaTeX are the only typesetting systems that can be used if mathematics is included or special formatting is desired. The abstracts submission page is at `http://www.ams.org/cgi-bin/abstracts/abstract.pl`. Simply fill in each field as instructed. Submitters will be able to view their abstracts before final submission.

Here are the codes you will need: Meeting Number: 1003; Event Code: the seven characters appearing after the title of the sessions shown above, e.g., MAA CP A1; and Subject Code: the last two-character letter/number combination from the event code list, i.e., A1.

All questions concerning the submission of abstracts should be addressed to `abs-coord@ams.org`.

Bowling Green, Kentucky

Western Kentucky University

March 18–19, 2005

Friday – Saturday

Meeting #1004

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: July 19, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Newark, Delaware

University of Delaware

April 2–3, 2005

Saturday – Sunday

Meeting #1005

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 2, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions

Homotopy Theory (in Honor of Donald M. Davis's and Martin Bendersky's 60th Birthdays) (Code: SS 1A), **Kenneth G. Monks**, University of Scranton, and **W. Stephen Wilson**, Johns Hopkins University.

Lubbock, Texas

Texas Tech University

April 8–10, 2005

Friday – Sunday

Meeting #1006

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 9, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses

Nikolai Ivanov, Michigan State University, *Title to be announced.*

Mattias Jonsson, University of Michigan, *Title to be announced.*

Nicolas Monod, University of Chicago, *Title to be announced.*

Hee Oh, California Institute of Technology, *Title to be announced.*

Special Sessions

Classical and Differential Galois Theory (Code: SS 3A), **Lourdes Juan** and **Arne Ledet**, Texas Tech University, and **Andy R. Magid**, University of Oklahoma.

Differential Geometry and Its Applications (Code: SS 2A), **Josef F. Dorfmeister**, Munich University of Technology, **Magdalena D. Toda**, Texas Tech University, and **Hongyou Wu**, Northern Illinois University.

Homological Algebra and Its Applications (Code: SS 4A), **Alex Martsinkovsky**, Northeastern University, and **Mara D. Neusel**, Texas Tech University.

Topology of Continua (Code: SS 1A), **Wayne Lewis**, Texas Tech University.

Santa Barbara, California

University of California Santa Barbara

April 16–17, 2005

Saturday – Sunday

Meeting #1007

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 16, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses

Mei-Chu Chang, University of California Riverside, *To be announced.*

Mischa Kapovich, University of California Davis, *To be announced.*

Mihai Putinar, University of California Santa Barbara, *To be announced.*

James Sethian, University of California Berkeley, *To be announced.*

Special Sessions

Dynamical Systems in Neuroscience (Code: SS 1A), **Eugene M. Izhikevich**, The Neurosciences Institute.

History of Mathematics (Code: SS 2A), **Shawnee L. McMurran**, California State University, San Bernardino, and **James J. Tattersall**, Providence College.

Recent Advances in Combinatorial Number Theory (Code: SS 3A), **Mei-Chu Chang**, University of California Riverside, and **Van Ha Vu**, University of California San Diego.

Mainz, Germany

June 16–19, 2005

Thursday – Sunday

Meeting #1008

Joint International Meeting with the Deutsche Mathematiker-Vereinigung (DMV) and the Oesterreichische Mathematische Gesellschaft (OMG)
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses

Helene Esnault, University of Essen, *Title to be announced.*

Richard Hamilton, Columbia University, *Title to be announced.*

Michael J. Hopkins, Massachusetts Institute of Technology, *Title to be announced.*

Christian Krattenthaler, University of Lyon, *Title to be announced.*

Frank Natterer, University of Muenster, *Title to be announced.*

Horng-Tzer Yau, New York University and Stanford University, *Title to be announced.*

Special Sessions

Algebraic Geometry, **Yuri Tschinkel**, Georg-August-Universität Göttingen, and **Brendan E. Hassett**, Rice University.

Discrete Geometry, **Jacob Eli Goodman**, The City College of New York, CUNY, **Emo Welzl**, Eidgen Technische Hochschule, and **Gunter M. Ziegler**, Technical University of Berlin.

Functional Analytic and Complex Analytic Methods in Linear Partial Differential Equations, **R. Meise**, University of Dusseldorf, **B. A. Taylor**, University of Michigan, and **Dietmar Vogt**, University of Wuppertal.

Homotopy Theory, **Paul G. Goerss**, Northwestern University, **Hans-Werner Henn**, Institut de Recherche Mathématique Avancée, Strasbourg, and **Stefan Schwede**, Universität Bonn.

Hopf Algebras and Quantum Groups, **Susan Montgomery**, University of Southern California, and **Hans-Jurgen Schneider**, University of Munich.

Mathematics Education, **Gunter Torner**, Universität Duisburg-Essen.

Nonlinear Waves, **Herbert Koch**, University of Dortmund, and **Daniel I. Tataru**, University of California Berkeley.

Stochastic Analysis on Metric Spaces, **Laurent Saloff-Coste**, Cornell University, **Karl-Theodor Sturm**, University of Bonn, and **Wolfgang Woess**, Graz Technical University.

Annandale-on-Hudson, New York

Bard College

October 8–9, 2005

Saturday – Sunday

Meeting #1009

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 8, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses

Persi Diaconis, Stanford University, *Title to be announced* (Erdős Memorial Lecture).

Johnson City, Tennessee

East Tennessee State University

October 15–16, 2005

Saturday – Sunday

Meeting #1010

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 15, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lincoln, Nebraska

University of Nebraska in Lincoln

October 21–22, 2005

Friday – Saturday

Meeting #1011

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2005
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 22, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions

Algebraic Geometry (Code: SS 1A), **Brian Harbourne**, University of Nebraska-Lincoln, and **Bangere P. Purnaprajna**, University of Kansas.

Eugene, Oregon

University of Oregon

November 12–13, 2005

Saturday – Sunday

Meeting #1012

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 12, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center

January 12–15, 2006

Thursday – Sunday

Joint Mathematics Meetings, including the 112th Annual Meeting of the AMS, 89th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).

Associate secretary: John L. Bryant
Announcement issue of *Notices*: October 2005
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2006
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 12, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 4–7, 2007

Thursday – Sunday

Joint Mathematics Meetings, including the 113th Annual Meeting of the AMS, 90th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).

Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 2006
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2007
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 4, 2006
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

San Diego, California

San Diego Convention Center

January 6–9, 2008

Sunday – Wednesday

Joint Mathematics Meetings, including the 114th Annual Meeting of the AMS, 91st Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).

Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2007
Program first available on AMS website: November 1, 2007
Program issue of electronic *Notices*: January 2008
Issue of *Abstracts*: Volume 29, Issue 1

Deadlines

For organizers: April 6, 2007
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Washington, District of Columbia

Marriott Wardman Park Hotel and Omni Shoreham Hotel

January 7–10, 2009

Wednesday – Saturday

Joint Mathematics Meetings, including the 115th Annual Meeting of the AMS, 92nd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).

Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: October 2008
Program first available on AMS website: November 1, 2008
Program issue of electronic *Notices*: January 2009
Issue of *Abstracts*: Volume 30, Issue 1

Deadlines

For organizers: April 7, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

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This book contains a detailed mathematical analysis of the variational approach to image restoration based on the minimization of total variation submitted to the constraints given by the image acquisition model. This model, initially introduced by Rudin, Osher, and Fatemi, had a strong influence on the development of variational methods for image denoising and restoration, and pioneered the use of the BV model in image processing. After a full analysis of the model, the minimizing total variation flow under different boundary conditions is studied and its main qualitative properties are exhibited. In particular, several explicit solutions of the denoising problem are computed.

2004/340 PP./HARDCOVER/ISBN 3-7643-6619-2/$129.00
PROGRESS IN MATHEMATICS, VOL. 223

Tubes

Second Edition

ALFRED GRAY, *University of Maryland, College Park, MD*

This second edition, which consists of newly added historical notes and figures in Mathematica, presents a comprehensive examination of Weyl's formula for the volume of a tube, its roots and its implications. Graduate students having a basic knowledge of differential geometry as well as researchers and instructors in the areas of analysis, differential geometry, topology, and mathematical physics will benefit from this excellent text.

2004/280 PP./HARDCOVER/ISBN 3-7643-6907-8/$89.95
PROGRESS IN MATHEMATICS, VOL. 221

Complex Convexity and Analytic Functionals

MATS ANDERSSON, *Chalmers University of Technology, Göteborg, Sweden;* **MIKAEL PASSARE,** *Stockholm University, Stockholm, Sweden; and* **RAGNAR SIGURDSSON,** *University of Iceland, Reykjavík, Iceland*

This book puts the modern theory of complex linear convexity on a solid footing, and gives a thorough and up-to-date survey of its current status. Applications include the Fantappiè transformation of analytic functionals, integral representation formulas, polynomial interpolation, and solutions to linear partial differential equations.

2004/164 PP./HARDCOVER/ISBN 3-7643-2420-1/$105.00 (TENT.)
PROGRESS IN MATHEMATICS, VOL. 225

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2003/236 PP./SOFTCOVER
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Meetings and Conferences of the AMS

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Southeastern Section: John L. Bryant, Department of Mathematics, Florida State University, Tallahassee, FL 32306-4510; e-mail: `bryant@math.fsu.edu`; telephone: 850-644-5805.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at** `www.ams.org/meetings/`.

Meetings:

2004		
October 16-17	Nashville, Tennessee	p. 715
October 16-17	Albuquerque, New Mexico	p. 716
October 23-24	Evanston, Illinois	p. 716
November 6-7	Pittsburgh, Pennsylvania	p. 717
2005		
January 5-8	Atlanta, Georgia Annual Meeting	p. 718
March 18-19	Bowling Green, Kentucky	p. 723
April 2-3	Newark, Delaware	p. 723
April 8-10	Lubbock, Texas	p. 723
April 16-17	Santa Barbara, California	p. 724
June 16-19	Mainz, Germany	p. 724
October 8-9	Annandale-on-Hudson, New York	p. 725
October 15-16	Johnson City, Tennessee	p. 725
October 21-22	Lincoln, Nebraska	p. 725
November 12-13	Eugene, Oregon	p. 725
2006		
January 12-15	San Antonio, Texas Annual Meeting	p. 726
2007		
January 4-7	New Orleans, Louisiana Annual Meeting	p. 726
2008		
January 6-9	San Diego, California Annual Meeting	p. 726
2009		
January 7-10	Washington, DC Annual Meeting	p. 726

Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 84 in the January 2004 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Several options are available for speakers submitting abstracts, including an easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. To see descriptions of the forms available, visit `http://www.ams.org/abstracts/instructions.html`, or send mail to `abs-submit@ams.org`, typing `help` as the subject line; descriptions and instructions on how to get the template of your choice will be e-mailed to you.

Completed email abstracts should be sent to `abs-submit@ams.org`, typing `submission` as the subject line. Questions about abstracts may be sent to `abs-info@ams.org`.

Paper abstract forms may be sent to Meetings & Conferences Department, AMS, P.O. Box 6887, Providence, RI 02940. There is a $20 processing fee for each paper abstract. There is no charge for electronic abstracts. Note that all abstract deadlines are strictly enforced.

Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (See http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

June 5-July 24, 2004: Joint Summer Research Conferences in the Mathematical Sciences, Snowbird, Utah. (See November 2003 *Notices*, page 1363.)

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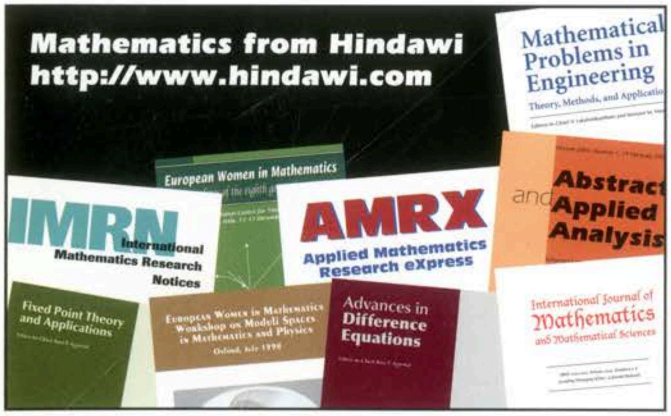

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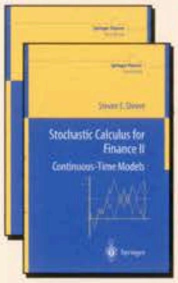

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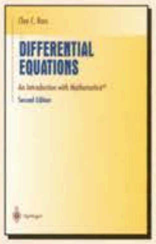

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